FIELD CROPS OF INDIA

WITH SPECIAL REFERENCE TO MYSORE

BY

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PREFACE

IN writing this book on the Field Crops of India, the author has been sustained throughout by the hope and belief that it will be found helpful to all who may be interested in Indian Agriculture as students, teachers, practical agriculturists, economists or officials of the various departments of Government who come in close contact with rural life. There are few books, perhaps, none at all published within recent years, which deal compendiously and comprehensively with the cultivation of all the important crops of the country. The Text-book of Agriculture by J. W. Mollison and that by N. G. Mukerji are about the only books that have long been available to the student. There are the sections on the various crops in that monumental work, the Dictionary of the Economic Products of India, which contain much useful information and which are available for reference. There are also special treatises, like Ridley's 'Spices', for instance, which deal with one or more crops of special economic importance. All these books are old, and some are very old indeed, and are anterior to the present epoch of extensive scientific research in the country. Most of the valuable information which has been the result of such work is available only in the form of special bulletins, articles in the different agricultural journals and other periodicals, and leaflets and circulars of the various departments of agriculture; these are all scattered and fragmentary and have to be fitted in their proper perspective and proportion into a full account of the particular crop, if it has to be presented to the general reader. Occasionally here and there, some of these departmental bulletins are quite in the nature of crop hand-books; these however are few and relate to only a crop or two. The author has thought it would serve a useful purpose if a book of a fairly comprehensive character dealing with most of the agricultural crops including the so-called plantation crops like coffee, tea and rubber, and drawing attention to such results of scientific work in each case as may be of practical application by the agriculturist, can be prepared and published. In deciding upon the scope and method of treatment to be adopted in such a work this object has been kept in view.

During the course of his long service of some thirty-five years in the Mysore Agricultural Department, in many capacities such as Chemist, Agricultural Teacher, Deputy Director and as Director, which has included several deputations both in India and abroad, and later

on during his retirement, as Officer on Special Duty under the Imperial Council of Agricultural Research and a member of some of its Committees, the author had maintained systematic notes for use not only in his day-to-day work but also with the object eventually that they may be worked up into some kind of a permanent record in the shape of one or more books, so that they may be useful to all those connected with or interested in Indian Agriculture. It was partly this desire and partly the pressing request by many friends that a text-book on the cultivation of the various important crops of the country should be written and their suggestion that the author could not leave a more fitting memento of his long career as an agricultural officer, which have induced him to undertake this work. The author is painfully conscious of the fact that the work has had to be carried out during his retirement from service, that he lacked the facilities which may be available to one in active service and that therefore to that extent shortcomings are likely. Nevertheless he has made the best use of such facilities as could be secured under the circumstances and has spared no efforts to make the book as comprehensive and useful as possible.

The need for a book on the various aspects of Indian agriculture including both crop and animal husbandry which is even now keenly felt will, almost to a certainty, be felt to a much greater extent in the near future. In the many-sided and large scale economic development which is proposed, planned and examined for post-war India, agriculture will claim and be accorded a very large share, not only in order to increase the food supply in the country but also to furnish in a larger measure than at present such agricultural products as provide the raw materials for many industries. Schemes for land reclamation and improvement for bringing more land under cultivation, schemes for increasing the facilities for irrigation of all types, schemes for the large scale manufacture of implements, manures and fertilisers, are al contemplated. In addition there are the schemes for the development of scientific research itself, for increasing the produce of the land, for evolving and multiplying high yielding varieties, for reducing the losses due to insect pests and crop diseases, for the better preparation of produce, for the utilisation of the bye-products and for ensuring a better money return to the producer, to specify only the more important directions for such action. The technique of crop raising must naturally form the central aim and pivot in these activities, and to this end, a comprehensive and practical treatise should make a valuable contribution.

Furthermore there is an increasing tendency for men not connected with agriculture to invest in land and to take to farming, both because the land is still considered the safest investment and farming a haven of refuge in these days of cataclysmic turmoil, and also because with sufficient capital, the cultivation of many economic crops

can generally yield a reasonable return. With the measures now being contemplated to put agriculture on a paying basis the attraction of the land is bound to increase. Large schemes of reclamation and colonisation are also adumbrated as forming part of post-war reconstruction, and quite a number of settlers on such reclaimed areas are not likely to belong to the traditional agricultural classes. Moreover, as in other countries so in India also, there is a steadily increasing exodus of people from the villages into the towns and cities; there is a large and marked change-over from the traditional and hereditary occupations to those less arduous and more attractive. The ryot leaves his plough, the potter leaves his wheel, the weaver leaves his loom, the village blacksmith his forge and even the priest leaves the temple, and all flock to the towns to exchange their hard village life and the precarious income from the land for the regular assured wages and the soft jobs in the various services in the cities. There is danger in the movement, of much traditional knowledge, the result of centuries of experience being forgotten and for agriculture to become less and less efficient. A full and reliable record of the agricultural practices will become an increasing need under the circumstances and one affording fuller information will mitigate to some extent the evils of the situation. To students, teachers and the educated agriculturists a practical account of this kind will not only furnish much needed guidance but will also form the starting point for such further knowledge as they may feel inclined to gather from other and special treatises and from actual experience. Outside India too, the want of a fairly comprehensive work of reference relating to the cultivation of the different crops in this country is keenly felt, and an attempt to supply this want will no doubt be welcomed. The importance and need for a book of this kind requires hardly to be further stressed. The author has kept in view readers of all these categories in writing it.

The crops dealt with in the book comprise practically every field crop of any importance in the country including the so-called plantation crops like tea, coffee and rubber. It does not include vegetables and fruits, although some of the crops dealt with may be classed under one or other of these kinds of crops. They number in all 58 and are dealt with under the different classes into which it is usual to divide them, *viz.*, grains, pulses, oilseeds, condiments and spices, fibres, drugs and narcotics, dyes, medicinal crops and so on. The classification may in certain cases be open to question, the grouping for instance, of coffee and tea under narcotics along with tobacco and hemp. The classification, however, happens to be the one adopted in the Official Crop and Season Reports and has accordingly been followed. It may also be considered that some of the vegetable crops which are occasionally grown on a field scale should have been included. The perishable nature of vegetable crops has been taken broadly as

their general characteristic and this is the basis on which these latter have been excluded from the list of crops dealt with. It is difficult to be very strict in reference to the crops on the border line, so to speak, and it is inevitable that in these cases the classification should be somewhat arbitrary.

The treatment of all the crops follows a uniform plan, which will be seen from the main paragraph headings in each chapter. The aim has been to make the subject matter regarding each crop complete and self-contained. In addition, therefore, to as detailed a description of the methods of cultivation as possible, including soils, rotations irrigation, drainage, etc., the subjects of manuring, of botany and varieties, of insect pests and diseases, of chemistry and the preparation of the main marketable product, are all separately gone into. Each chapter concludes with a brief statement of the acreage, production, exports and imports of the particular crop. Although the aim and endeavour have been to make the treatment comprehensive on the whole still attention has been paid mainly to those aspects of cultivation and other matters which have a practical bearing. Matters of pure scientific importance are either left out or touched upon only briefly, and as far as they may be related to actual methods of cultivation, to the selection of varieties, or to the control of pests and diseases. Thus in the botany of the crops, the description of the varieties of economic importance receives the main attention rather than the strictly botanical characters; in respect of pests and diseases, the outward signs of the disease or attack, their mode of spreading, and the methods of control, receive attention more than the life histories of the pests or the morphology of the fungi concerned. Moreover among the pests and diseases only the major ones and those of frequent occurrence are dealt with and others are only briefly referred to. General principles underlying agricultural practices are however explained and emphasised in the appropriate places, such as the treatment of special soil types, the principles of dry farming, the importance of drainage, the principles and methods of manuring and so on. An endeavour has been made to embody as far as possible published results of scientific work to the extent, however, that they may be of immediate practical application. One cannot but observe in this connection that out of the very large bulk of scientific work in the country results answering to this description are comparatively small. This is painfully evident in the case of control measures against pests and diseases, a matter in which even the best among our agriculturists feel helpless and resort to the help and advice of the departmental officers. There are also many other aspects of cultivation in which the lacunæ in our knowledge are many and important, notably for instance in respect of the relation of soil types to crops, plant diseases, manuring, the feeding values of many pulses, the varietal characters of

many of the minor crops and so on, which all await further research. Such as they are, however, the results of scientific work have been availed of, as fully as possible, in the treatment of each crop.

The chapters on the different crops are by no means exhaustive monographs, and specialist readers may find them not as full as they should be. The author would only plead in extenuation that the book is largely intended for the ordinary reader interested in agriculture and that considerations of space in a book which deals with such a large number of crops put an inexorable limit to the length of the chapters. Some results of importance which may have become available since the book was written could not obviously be included and therefore may be noticed as omissions. This is specially probable in respect of improved varieties. The plant breeder is busy everywhere and new and better varieties are being rapidly evolved, to which the older ones have to give place. In fact it is not at all unlikely that by the time this book reaches the public some of the varieties listed and described under sugarcane, cotton or rice, for example, may become back numbers. The author has also eschewed, except in the case of a few crops, going into the money values of operations or produce; the frequent and violent fluctuations in the price of produce and the large variations depending upon the time and place in the items making up the cost of production, make such figures either valueless or positively misleading. The few cases in which such figures are given only serve to emphasise this point. Making allowance for these features in the book, the author hopes that each chapter is so comprehensive that few readers of the ordinary type who may turn to its pages for help or guidance will go disappointed.

The methods of cultivation described in the book are mainly those which are prevalent in the Mysore State. Notable or interesting differences which may exist in other parts of the country are also referred to wherever their importance may warrant it. Though the matters dealt with are largely based upon the author's own work and notes, ranging over a long period of time both inside and outside of Mysore, still a large variety of other sources has been availed of to the extent possible. Among these are many of the standard books on special crops, the publications of the Mysore and other departments of agriculture, the various agricultural and allied journals both Indian and foreign, (notably Malaya, Ceylon, and the Netherlands East-Indies) and other publications. A list of the principal ones among these is given in the Appendix. The author's indebtedness to all these books and publications and to the writers of the different articles which have been made use of is very great and he takes this opportunity to acknowledge it with gratitude.

The author has received very material help from various Governments and their officers. The Government of His Highness the

Maharaja of Mysore have been chiefly instrumental in enabling him to publish the book. The Government of India have permitted the Imperial Council of Agricultural Research to lend to the author the blocks of illustrations that have appeared in the various Marketing Reports and in "Indian Farming." The Director of Agriculture in Mysore, the Director of Agriculture in Ceylon, the Superintendent of Sericulture in Mysore, the Secretary of the Indian Jute Committee and the Millets Specialist in Coimbatore, have likewise been good enough to permit the use of the blocks belonging to their respective departments. The Superintendent of Government Printing in Mysore, Mr. B. Krishnaswami Chetty, B.E., has, despite great difficulties for suitable paper and the pressure of Government work, put the book through with much promptitude and with excellence. To all of them the author wishes to express his deep gratitude.

The author is not unmindful of the fact that there may be omissions and inaccuracies, but trusts that they are not such as to detract from the value of the book. In conclusion he would express the hope that the book will achieve the main object of its publication and afford both helpful guidance and knowledge to all those for whom it is intended.

—THE AUTHOR.

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FIELD CROPS OF INDIA

SECTION I

THE GRAIN CROPS

I. RICE (Oryza sativa)

VERNACULAR NAMES FOR RICE (unhusked or paddy)—
Kannada-BHATTA, *Tamil*-NELLU, *Telugu*-ODLU,
Malayalam-NELLU, *Hindustani*-DAN.

Distribution, altitude and climate.—The rice crop has the distinction of being the most extensively cultivated crop in the world and of being the staple food crop of the largest population. The world's rice area is estimated at about 134 million acres and the population fed by the crop at 95 per cent of the world's total population.

The rice plant belongs to the order Gramineæ and it is remarkable that the whole of this immense cultivated area of the world is under a single species, *viz.*, Oryza sativa, although the varieties therein are very large in number, running into hundreds. Rice has an extensive range of cultivation; it occupies not only the tropics, but extends far into the temperate zone. It is *par excellence* an Asiatic food crop; Southern, South-Eastern and Eastern Asia form the largest rice-growing part of the globe and the largest rice-eating population also belongs to this area. The cultivation however has been taken up in other parts of the world also; in Europe, Northern Spain and Italy are important rice-growing countries, in the United States rice is grown extensively in the States of Louisiana, Texas, and the Carolinas. In British Guiana, many West Indian Islands and the Northern and Eastern Provinces of Australia considerable rice is grown. The range of latitude may be said to extend from the 40th parallel North Latitude to the 30th parallel South Latitude. Temperature however sets a limit and in the higher latitudes only in the warm months of summer can rice be grown. Rice is grown from sea level up to an altitude of about 5,000 feet as a maximum. On the Mysore plateau which has an elevation of about 3,000 feet rice is an important crop, grown in all seasons of the year and over extensive areas and giving fairly heavy yields. The same may be said also of the mountainous Province of Coorg where rice is grown at an altitude of 4,000 feet. In the higher altitudes with their milder temperature, the growing

period is more prolonged and the maturity delayed than in lower altitudes or sea level, and the so-called short-season varieties which are said to mature in three months or less take a considerably longer period to mature.

Rice is grown in the almost rainless valleys of Afghanistan, in the flat damp hot plains of Lower Bengal, in the coastal deltas and in the hill ranges of Kashmir. Rice can be grown over a wide range of rainfall. In the districts adjoining the Western Ghats where the rainfall exceeds 200 inches in the year, rice is grown as an important crop, it is in fact the only food crop that can be grown. Where the rainfall is at least 25 inches in the growing season, rice can be likewise grown safely as a rainfed crop. At the other extreme where the rainfall may be even less than ten inches, excellent crops are raised under well irrigation. Rice is thus certainly unique in respect of the wide range of conditions such as latitude, rainfall, distance from the coast and altitude, under which it can be grown.

Soils.—The soils on which rice can be grown are so extraordinarily varied that it can be said that there is hardly any type of soil on which it cannot be grown, including alkaline types, of a fairly high degree of alkalinity. Damp alluvial soils, black clayey loams, light sand, gravels or stony soils, deep soils, exceedingly shallow soils, soils with a high lime and alkali content and even boggy soils in which the soil is composed of fine, almost floating, mud—can be seen to be cultivated with rice. Steep hill sides are carved and laid into terraces for rice cultivation with the most painstaking labour; and flat land subject to inundation and complete submergence for part of the year is also cultivated with rice. The channel irrigated rice fields in the Mysore district are in many tracts so gravelly and even stony that crop-raising will be considered almost impossible; the hoofs of the ploughing cattle and the fingers of the transplanting coolies become badly worn and pitted, when working on these fields.

Soils are so fine and soft in certain places that ploughing with bullocks or buffaloes is a dangerous operation as they sink too deep and the fields are therefore prepared only by digging with manual labour. In certain rocky situations rice fields can be seen on very rocky soils which are very shallow and only a few inches deep and underlaid by rock. It is very noteworthy that, hard as many of these conditions may seem, fairly moderate yields are generally obtained. The best rice soils are clayey loams of the kind seen on flat land under tank irrigation and in river deltas. They work into a soft mud when puddled and when dry develop deep cracks.

Rice is cultivated practically as a semi-aquatic plant; but there are varieties which are cultivated exactly like a dry grain such as 'ragi' or 'jola' and in mixtures with dry crops like 'togare' or cotton solely with the aid of the rainfall and with no

impounding of water in the standing crop at all. Others are raised as rainfed crops, in low situations where water may stand for some days; but they can also withstand considerable drought when the water drains away and the rains cease, for several days—conditions under which no other crop can be grown with confidence.

Laying out rice fields:—The cultivation of rice is carried out in many different ways but a most important preliminary is the laying out of the fields for this purpose. The cultivation of rice except in the somewhat rare instances of dry cultivation, requires that irrigation water should stand evenly over the field practically throughout the season and be capable of flowing out in a gentle flow, the level of the water in the field being kept up at the same time. Fields have therefore to be level and surrounded by firm, fairly water-tight bunds. The size of the fields has to be suitable therefore both for the purpose of impounding the water at an even depth and to permit of a flow. On sloping ground and undulating country or the sides of hills, the difficulty and expense of making any deep cuttings and somewhat large terraced fields sets an additional limit to the size of the fields. Often cuttings cannot be made deep and the terraces are therefore higher than the nature of the lower layers of the soils will allow; sheet rock, partly decomposed rock or thick gravel or very raw unweathered clays may lie within two or three feet of the surface and the terraces cannot in such circumstances be made higher to permit of larger fields. The steeper the slope the smaller and more numerous the terraces and the narrower are the fields. In the channel tracts of Mysore, this terracing for rice cultivation may cost from Rs. 25 upwards to double this figure or more according to the nature of the slope and the kind and depth of the soil. Fields seldom exceed one-tenth of an acre and are generally very much smaller, those of even one-fortieth of an acre being found. The irrigation water has to flow from the upper terrace to the one below and so down the slope and a continuous flow kept up so as not to deprive owners of fields in the lower terraces of an adequate supply to their fields. Fields have therefore to be small enough to impound the necessary water and allow a flow outside without any scouring. On level flat land such as under tank or well irrigation fields can of course be made very much larger, the only provision to be safeguarded being the keeping up of a uniform depth both at the inlet end and at the outlet end, without impairing the gentle flow from one end to the other. Fields of about a fifth to a fourth of an acre are easily possible; but in practice even here the fields are made much smaller and even ridiculously so; even when these small pieces form part of one single block in the possession of one single person, these divisions are made. The land taken up by the dividing bunds in these highly divided fields is considerable. There is furthermore the

difficulty of ploughing these little areas which entails much loss of time and labour. Where cultivation is of a high order the field bunds are kept trimmed thin and at the minimum necessary, but where cultivation is of the ordinary type or poor and neglected, the field bunds are often a yard wide and exceedingly wasteful. The saving that can be effected in both these directions, *viz.*, the increased area and the saving in bullock labour if these fields can be thrown together and made large, is very material and is indeed one of the main grounds for effecting consolidation. In certain provinces the Survey department refuses to take note of fields smaller than a particular limit in their accounts, but neither the advantages of consolidation nor this rule of the Survey department has deterred cultivators from splitting up the fields into often absurdly small plots. Fields should be laid out as far as possible into suitable rectangles and as large as the surface of the tract will allow, consistent with the requirements of irrigation indicated.

Seasons for Rice :—It is a very noteworthy characteristic of the rice crop that it has a very wide range of seasons, to such an extent indeed that it may not be unusual to see the rice crop in all stages of growth at the same time in one and the same neighbourhood. Rice may be sown or transplanted, grown halfway through, in earheads, maturing and even being harvested at about the same time. This is largely the result of the existence of a large number of varieties which are adapted to particular seasons having varying periods of maturity. This peculiarity of the rice crop enables the cultivator to manage with a small equipment by way of ploughs, bullocks and men a fairly large area, which will not be possible if the rice could be grown only in one season. Broadly, however, the rice seasons may be said to be two : (1) called the rainy season or the main crop which is sown approximately about June-July and harvested in November-December and (2) the hot weather crop which is sown after December up to about February and harvested from May to June. In the Mysore District the former is called the Hain crop and the latter is called the Kar crop, and elsewhere in the State the two are called by the names Karthika and Vaisakha crops respectively. In the Madras Tamil districts the two go by the names of Kar and Pisanam respectively.

The main or rainy season crop is usually a long season crop taking from 5½ to 7 months to harvest and is grown in many different ways, *viz.*, dry or puddle and in the latter " dry seed " sown, or " sprouted seed " sown or transplanted. The Vaisak or hot weather crop is usually a short season crop taking about 4½ months to mature. Specially early maturing crops such as those maturing from 75 days to 100 days are also sown only in this season although there are a number of medium duration crops which mature between 4½ to 5 months, which are sown in the main season. The so-called " kar " or hot weather crop

is sown in parts of the Mysore District from as early as the month of October and continued through almost to the month of June when it really coincides with the main rainy season. These are given separate names depending upon the months in which they are sown or transplanted thus:—(1) 'Tula' Kar—the first to be sown, is sown in puddle in the middle of October or transplanted in the middle of November, (2) 'Kumba' Kar—which is really the correct season—is sown'dry' in December or in puddle in the beginning of January or transplanted at the end of January, (3) 'Mesha' Kar—which is the last, is sown or transplanted from the beginning of April to the beginning of June.

Varieties of rice are such as can be sown in either of the two seasons, or in only any one particular season. Much care has to be exercised in selecting the variety to grow according to the season, especially when introducing varieties from other provinces or from different tracts. The peculiarity of varieties in this respect consists in the fact that some take a definite period of time to come to maturity, while others come to maturity only in a particular month or season irrespective of when they are sown. Varieties like Banku or G. E. B. 24 which are raised as medium short season crops and are sown in the main or rainy season in the months of June-July, mature and are ready for harvest by about October. If however they are attempted to be raised as a hot weather crop and are sown, say, in January or February, they keep on growing and do not mature until about October; as a matter of fact, the water supply usually gives out as the hot weather advances and the crop does not live to mature at all. The duration of varieties is also considerably altered by the prevailing climate. Short duration varieties which mature in sixty days in the hot plains of the Madras districts take a considerably longer period if grown in the cooler climate of the Mysore plateau. Varieties brought over from Madras as 60 days or 90 days varieties have always taken from 100 to 120 days in Mysore.

The existence thus of varieties with different durations makes it possible to grow not only two crops of rice in the year on the same field which is usual but also sometimes three crops where there are ample supplies of water. It makes it possible further to grow a rice crop even at times and in situations when the water supply can last only for two or three months.

Methods of Cultivation.

Puddle cultivation and "dry" cultivation.—The methods of rice cultivation may be broadly divided into two classes, *viz.*, (1) cultivation in puddle and (2) "dry" cultivation.

The cultivation in puddle may itself be in three ways, *viz.*, the sowing of the seed after sprouting it first, the sowing of the raw untreated seed, and transplanting seedlings raised separately in nurseries. The puddle cultivation is adopted where the supply

of water is from river channels, tanks, or wells and where it is abundant and assured from the time the land has to be prepared to the harvest of the crop. In such areas both the methods sometimes may be adopted, the dry sowing being in sections where it may be desirable to start the cultivation earlier and sometimes in the higher levels. In tank-fed areas the rainy season crop that is sown in June and harvested about November December may often be entirely on the dry system; the preparation of the field and the first two or three months of the growth of the crop are by this means carried on with the help of the rainfall, and the latter half of the growth with irrigation from the tank, which by that time receives sufficient supplies to meet the needs of the rice crop; under other tanks the whole area may be under puddle cultivation, either because of the large supply in the tanks or because the cultivation may commence somewhat later and after the tanks have received their full supply. In still other tanks, especially those that receive their big supplies in the North-East monsoon, no rice cultivation is taken up in the rainy season at all or, if attempted, is only on a small extent and then only by the dry method. In these areas the rice cultivation is taken up only in the Vaisak season and then is entirely on the puddle system. Under well irrigation the cultivation is always by the puddle system. The dry system of cultivation is the general rule in the tracts of heavy rainfall, such as the Malnad districts, where rice is cultivated solely with the help of the rain and seldom from any storage tanks or through any river channels.

I. *Puddle cultivation—Broadcasting.*—The cultivation by the puddle system is itself carried on in three different ways; in one the seed is sown after being previously sprouted slightly, in another the seed is sown raw and untreated and in a third seedlings are separately raised in a nursery and are then transplanted in the puddled field. Whichever method is adopted, the preparation of the field is alike for all. The preparation of the soil commences about a month or three weeks before the sowing or the transplanting has to be done and consists in flooding the field, and then ploughing it while the soil is not only fully soaked but the water stands about two or three inches deep in the field. Ploughing and cross ploughing are repeated with short intervals of a few days for rest during which water stands in the field or the field is sodden wet. Four to six ploughings are given depending upon the efficiency of the ploughing; a thorough stirring of the soil and complete puddling is necessary and the time interval is also an essential factor; these are all calculated to bring about the proper mechanical condition of the soil and the crop responds suitably to liberal treatment in this respect.

Considerable saving in the expenditure of puddling can be effected by the use of mould-board ploughs and of cultivators

with three or six tynes but it is essential that every inch of the soil should be turned over in the puddle. In fact the thorough puddling of the soil and bringing it into proper consistency with the water is a most important difference between this method and the dry sowing method, which brings about chemical and bacterial changes in the soil peculiar to itself and which has a bearing upon the fact that any dry ploughing as a preparatory cultivation has been found to be harmful for the rice crop raised by the puddle system. The ploughing of the field immediately after harvest, and if possible more than once and allowing it to weather in that condition has been found beneficial only in "dry" or non-puddle cultivation. Where a green manure crop is grown to be ploughed in, it is cut down and is ploughed in in the puddle where it rots and disintegrates in the intervals between the ploughings. If the green manure crop is a tall growing crop like sannhemp or 'daincha,' it will have to be cut into short lengths, so that it may not interfere with the ploughing. Low growing crops like horsegram, cowpea, wild indigo, etc., can be ploughed in as such. *Green manure is more often brought from* elsewhere, the chief among these being the leafy branches of Cassia auriculata, wild indigo, (Tephrosia purpurea) Pongamia glabra, Calotropis gigantea and so on. Sannhemp likewise may also be grown elsewhere and brought in. In these cases the green material is spread on the puddle and trampled in at the last ploughing. Cattle manure is seldom applied where green manure is grown and ploughed in, but under good cultivation, especially under well irrigation, and also where green manure cannot be applied, cattle manure is spread over at one of the later ploughings and ploughed in. The puddle is now smoothened either by working a levelling board or by coolies walking over and smoothing down any inequalities in the surface. The field is now ready to receive the seed, sprouted or raw, or the seedlings to be transplanted. These operations take nearly a month to complete.

Preparing sprouted seed.—The sprouting of the seed is effected in the following way :—

The seed paddy is first soaked in water either overnight or a whole day; for this purpose it is put in a pot and water is poured into the pot until it covers the seed paddy or it is tied up in an ordinary gunny bag and kept under water, or tied up in baskets or receptacles made of straw twists and then kept under water. After 12 to 24 hours the water is allowed to drain away and the seed is heaped up on the ground and covered over with mats and weighted down with stones. In some places leaves of castor, Calotropis gigantea, Dodonia viscosa, Phlomis esculenta, etc., are used for covering the seed paddy and are believed to possess special virtues in this respect. On the third day they are removed, water is sprinkled liberally over the heap, which is turned over and again left covered with the leaves and weighted

by the stones. Elsewhere a certain amount of well powdered cattle manure and ashes are mixed up with the seed at the time and the heap is turned over. The process is repeated on the third day also and on the fourth day the seeds are well sprouted and are ready for sowing. Sprouting can be induced by merely keeping the straw baskets well moistened after they are taken out of the water, a practice followed in some places. In four days these seeds too germinate and become ready for sowing. Sprouting is complete in a period varying from 48 to 96 hours according to variety.

The seed paddy itself whether for sowing as such or after sprouting may with advantage be subjected to a preliminary process of selection by which the lighter seeds are separated and removed and only heavy seeds are selected. This process consists in pouring the seed paddy into a vessel containing water with common salt dissolved in it, the quantity of salt to be used being as much as the water will dissolve completely; on stirring up the paddy a certain quantity which consists, of course, of the light seeds floats and this is ladled off; only the portion which sinks is used for seed purposes. The process does not take more than a few minutes and the germination is not affected at all in any manner. As against unselected seed, the selected heavy seeds give a better stand and an increased yield.

Sowing and after-cultivation.—Both the field and the seed having thus been prepared, the sowing commences, and with water standing about an inch over the puddle, the seed is sown broadcast; on the following day when the seeds have sunk in the soft mud, the water is drawn off for a day. The next day water is let in and made to stand one inch deep and drawn off again the following day. This alternate watering and draining is continued for a week or ten days until the seedlings are well up and can stand heavier irrigation. Cattle manure or oil cake or artificial manure may be applied by strewing it thinly during one of the days when the field is drained off during this week. Irrigation is now given more liberally and more and more water is made to stand in the field as the seedlings grow up. After about three weeks from sowing, weeding is done by means of a light harrow and subsequently by hand labour. At the first weeding an additional dose of manure, either oil cake or artificial manure, may be applied and water retained in the field by stopping both the inflow and the outflow for a couple of days. In the same way, oil cake or artificial manure may be given at one of the later weedings also, in case the crop appears to be in need of manure. At the last weeding which usually takes place about the third month, the young shoots or tillers appearing newly are also pinched off. Water should be allowed to remain up to about four inches in the field in a state of slow continuous flow almost up to the harvest. Any shortage of water results in poor development of the earheads, in grains not

filling properly, resulting in much smaller grain or too much chaff or in grains not developing into large plump ones. Water is cut off only about ten days before harvest, and for a day or two before the harvest is to commence the field is further drained by means of small furrows.

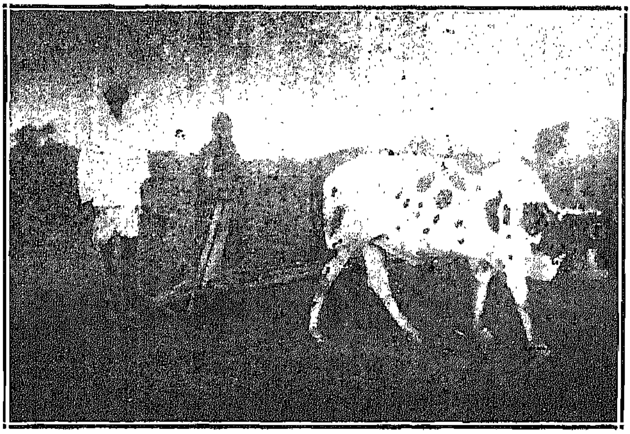
Transplantation: Raising nurseries.—Where the field is to be transplanted, seedlings are raised in a separate nursery. The nursery is made by one of two methods, *viz.*, one which may be called "wet" and the other "dry." For the wet nursery, the soil of a small selected field is prepared in the same way as for the puddle cultivation described above, that is to say, the field is flooded, ploughed in puddle, the water drawn off, ploughed again, drained and this process repeated until a very fine puddled condition is obtained. Cattle manure is spread and sometimes green manure is trampled in. Sprouted seed is sown very thick at the rate of 15 to 20 lbs., per 'gunta' ($\frac{1}{40}$ acre), or 600 to 800 lbs., per acre in the soft mud with about an inch of water standing in it; the water is drained off the next day; water is let in again the third day and drawn off the following day, this being repeated once in three days until the tenth day when water is let in and allowed to stand almost one inch deep for a week, after which the depth of water is gradually increased up to three inches. The irrigation is continued without a break until the 35th or the 40th day when the seedlings are usually pulled out for transplanting. Instead of sprouted seed, untreated seed can also be sown; in that case, the nursery should be watered for the first three days continuously, the water then drawn off, and cattle manure thickly scattered over, and then the watering resumed on the fifth day and regulated in the same way as when sprouted seeds are sown.

In the 'dry' nursery, the nursery plot is given a soaking irrigation to soften it, and when it has dried slightly it is dug thoroughly and prepared; clods are broken, weeds gathered and removed and the ground well harrowed and brought to a fine tilth; it is laid into narrow beds about three feet wide and separated by furrows, the beds being slightly elevated. Cattle manure is spread in the beds and well worked in. The beds are now irrigated along the furrows to give the beds just the amount of moisture required for germination of the seeds without flooding the surface. Seed is now sown thick and harrowed or stirred in into the beds and another layer of cattle manure and ashes spread on the surface. Every day enough water is let into the furrows and is splashed on to the surface of the beds to keep the surface moist. After the seeds sprout and are well established watering is given once in two days always by splashing or hand watering and not by flooding. The seedlings grow under somewhat hard conditions and do not attain the same height at transplanting time as seedlings raised in puddle and are suited to conditions where transplanting has to be delayed.

A nursery of a 'gunta' of land ($\frac{1}{40}$ acre) will generally furnish seedlings enough for a quarter of an acre, but this ratio, 1 of nursery to 10 of transplanted field, is subject to much variation depending upon the quality of the seed, the thickness of sowing, closeness of transplanting, number of seedlings per hole and the general excellence of the cultivation; on an average it seldom goes below 1 : 6. Under ordinary conditions of transplanting a ratio of 1 : 8 at least will have to be adhered to.

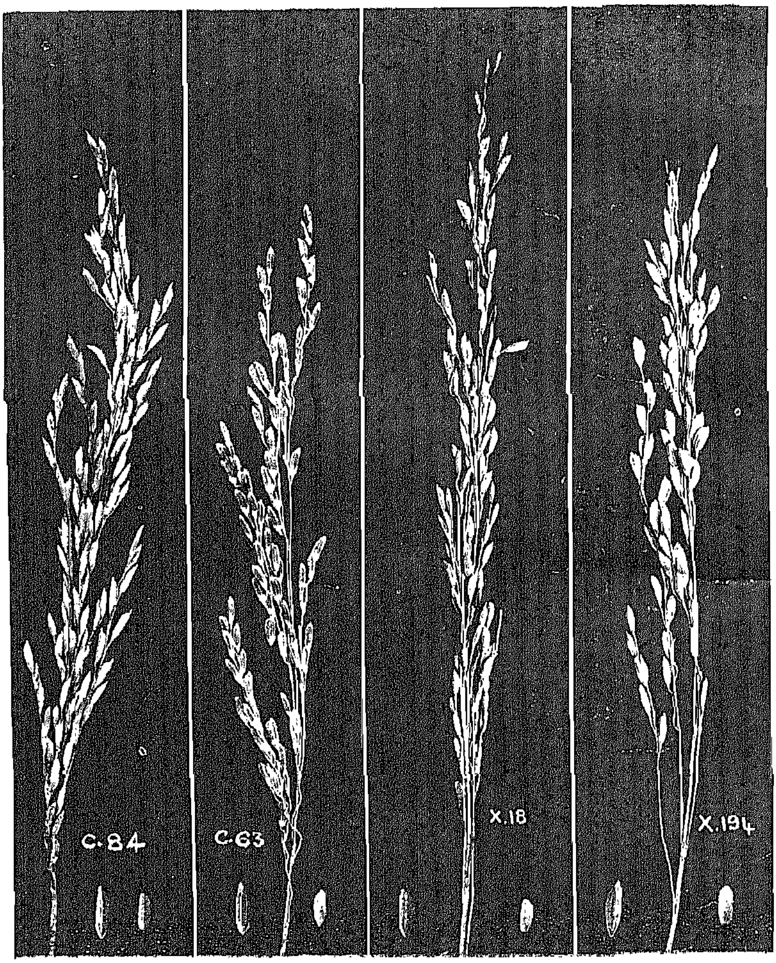
Transplanting.—In the puddled field prepared and kept ready as already described, these seedlings raised in either of the above two ways, are now transplanted. The nursery beds, whether dry or wet, are given a good soaking irrigation so that the seedlings can be pulled out easily and without undue injury to the roots. They are pulled out either on the same day as they may be required for transplanting or the previous evening; they are put up in small bundles such as can be held in one hand and tied up, the roots are well washed to free them from adhering mud, and the bundles are taken in cart-loads or head-loads or slung across the shoulders in a couple of baskets to the field for transplanting. In some tracts it is the practice to allow the plants to wilt somewhat, by piling them up in a circular pile arranged with the roots outwards and the green tops inwards. The leaves slightly yellow in the process and it is claimed for this practice that borer larvæ and eggs are killed out by the heat. After the seedling bundles are brought to the transplanting field, they are distributed on the field conveniently for the transplanting coolies who untie the bundles, remove the seedlings in bunches containing from three to ten (or even more) plants and plant them in the soft mud, at distances of six to nine inches. The transplanting is done in the field with about one inch of water standing on it. On the following day the water is drawn off and irrigation is resumed only after three days, the water being let in during the day and drawn off at night. This kind of light and regulated irrigation is repeated at intervals of two or three days depending upon the retentiveness of the soil; during this period the yellow colour of the seedlings, developed after they were transplanted, slowly turns to green and in about fifteen to twenty days the change is complete and it is also an indication that the plants are well established and can stand the normal irrigation for the crop. From that time onwards the water is made to stand in the field and a continuous flow is kept up with the water standing about three to four inches deep, till the crop matures. Transplanted fields do not require the same amount of weeding as broadcasted fields, but some two hand-weedings are given as may be required, the first when the crop is a month old after transplanting and the second another three weeks thereafter.

Seed rate per acre—(a) In broadcasting.—The seed rate per acre varies somewhat according as the seed is sown broadcast or



Sowing rice with a three-tyned seed-drill in the Mysore Malnad.
[Mys. Agri. Dept.

The Transplanting of Rice. [Mys. Agri. Dept.



Earheads of some of the superior rice selections of the Mysore Agricultural Department. [Mys. Agri. Dept.

sown in drills. When sprouted seed is sown, for example, there is no loss of the seed and nearly every seed gives rise to a plant, whereas when dry seed is sown, there is a certain amount of loss due to their being picked up by birds, and ants and some seeds failing to sprout at all. The rate can therefore be reduced when sprouted seeds are sown. The seed rate for broadcasted seed varies from fifty seers to seventy seers (1 seer being equal to 1·7 lbs.), the rate for sprouted seed being about fifty seers, and for dry sown seed being seventy seers. For drill-sown seed in the Malnad the rate is about midway and may amount to fifty-five or sixty seers. For seeds sown as 'Salubatta' that is, in plough furrows, the rate is very low and is twenty-five seers. There is considerable variation however and generally seeds are sown much in excess of real requirements as a precaution against loss and poor germination.

(b) *In transplanting.*—For transplanted rice also there is much variation in the seed rate according as nurseries are sown thick or thin, or as the seedlings are transplanted in bunches of several seedlings or in singles, or two's and three's or such small number Raiyats' nurseries are invariably sown thick. A very large number of experiments have been conducted in nearly every experimental farm in South India on the subject of seed rate for the nursery, on the number of seedlings for transplanting and on the spacing for the seedlings so transplanted. In drawing conclusions from these numerous experiments it must be stated that they are all prior to the introduction of the new statistical technique for field experiments now invariably adopted although they were generally laid out in duplicate or triplicate and interpreted according to the then practice. This same remark applies also to the manurial and varietal and other experiments on rice which form a large bulk of the work on these farms.

Seed rate for transplanted rice.—The seed rate for transplanted rice can be as low as 12 seers an acre (about 20 lbs.) but often goes up to fifty seers an acre or about four times the quantity. It is even stated that the rate in some tracts goes up to 100 seers an acre. As a matter of fact if seedlings are planted in singles and a spacing of 6″×6″ is adopted, the number of seedlings required will be given by as little as ten lbs., and in many experiments the 12-seer seed rate has yielded larger crops than those with higher seed rates. Between this theoretical lower limit and the very high rates noted above practical considerations have introduced many variations. The size and variety of the seed and its general quality, the distance of planting seedlings and the number of seedlings that are or have to be transplanted and above all the need for having to provide against loss, by washing away, poor growth or low vitality of seedlings are all to be considered in adopting a suitable rate. On the whole it may be said that the

seed rate should in average circumstances be between 40 and 50 lbs., per acre, this quantity being sown in a nursery bed of one-tenth an acre.

Spacing for seedlings.—As regards the most advantageous spacing of the seedlings in transplanting there is no doubt that as far as tillering and cropping power of individual plants are concerned, the wider the spacing, the better it is; but from the point of view of the yield per acre, the spacing cannot be increased beyond a certain limit; a wider spacing also leads to uneven ripening as some of the later tillers mature after the bulk has matured. From both points of view an economic spacing has to be fixed and this is found to be between four and six inches. Longer maturing varieties and better tillering varieties can be transplanted within limits of six and nine inches. Seedlings can be transplanted 6″×6″, 6″×9″ or 9″×9″. There is nothing to be gained by increasing the spacing any further.

Number of seedlings to be transplanted.—The number of seedlings to be transplanted in each hole has also formed the subject of many experiments and the planting of single seedlings has been largely recommended. There is no doubt that strong well-grown seedlings in well manured fields, in tracts of ordinary rainfall, yield better crops than seedlings planted several in a bunch or at least are equal in yield to the latter. In this case the saving in the seed rate is an obvious advantage, while in the first there is the additional yield also in its favour. For various reasons, however, in practice it is found necessary to increase the number of seedlings per bunch. In the heavy rainfall districts of the Malnad where it is not uncommon to find water not only covering the young rice fields but flowing over the field with considerable force, a matter of first importance is to see that the seedlings are not washed off or rot away. To guard against this risk, seedlings are planted in bunches of fifteen or twenty and sometimes even more. Even in ordinary circumstances a much larger number is planted than would appear necessary. In both situations the number can be reduced with advantage, taking care however, that seedlings are strong and well grown. In the 'maidan' districts the number can be reduced to three or two or even one, depending upon the conditions of the field and the seedlings and the labour available, while in the Malnad, the number can be reduced to four or five, excepting in the specially flooded areas.

Age of seedlings.—The age at which seedlings should be transplanted has also been the subject of numerous experiments. As a rule, for ordinary guidance the practice of allowing one week for the seedlings for every one month of the maturity period of the particular variety is adopted. Thus, if a variety is one which takes six months to mature, then seedlings can be allowed to grow in the nursery for six weeks and then transplanted; and in the case of a four

months' variety for four weeks and so on. It is seldom, however, that a period of fifty days is exceeded. The underlying idea is that after the seedlings are transplanted there should be a sufficiently long interval for the seedlings to establish themselves and tiller to their maximum capacity before the next stage in the growth, *viz.*, the formation of the internodes and the lengthening of the stems begins. Obviously therefore the earlier the variety the shorter the length of time that the seedlings can remain in the nursery. Seedlings are never left in the nursery if it can be helped up to the stage when the internodes begin to form. Where nurseries are raised 'dry' the seedlings do not make the same rapid growth as they do in wet nurseries and so the seedlings can be left a little longer in 'dry' nurseries. The minimum period for which seedlings can remain in the nurseries is a matter which is decided by the growth and condition of the seedlings; if these are considered sufficient to enable the seedlings to overcome the shock of transplanting and establish themselves properly in the transplanted fields, then they can be removed from the nursery. A period of not less than twenty days will be required for this purpose and this may be deemed the minimum for the nursery stage. Nurseries in poor condition brought about by insect pests, exposure to high winds laden with sandy dust, poor soils, etc., should be given a dose of sulphate of ammonia to stimulate the growth so that they may attain the required condition without exceeding the age proper for the variety.

II. "Dry" ploughing and cultivation.—In the second system of cultivation, *viz.*, the dry system two methods may be distinguished. In one which is confined to the districts of heavy rainfall such as the Mysore Malnad, the crop depends entirely on the rainfall, and in the second which is common elsewhere the cultivation depends partly upon the rainfall and partly upon irrigation, the crop being started and continued about half way through, so to speak as a dry crop, and finished off as an irrigated crop or as in the puddle cultivation. An interesting feature of the first system is the use made extensively of bullock drawn implements for work which elsewhere is largely done by manual labour. The methods may now be described.

(*a*) *Malnad cultivation.*—The method of preparing the field is very much the same as for dry crops. The first ploughing is done soon after the harvest of the previous crop of rice, that is, as soon as the ground becomes dry enough to take the plough. The field is left in this condition until the first rains are recieved, when the field is worked with the heavy bladed harrow called "dodkunte" or with the heavy log called "koradu", both of which break the clods. The "dodkunte" is worked twice again, during which process the clods are broken still further and the weeds are all freed from the clods and brought to the surface. Bullock hoes having three or more iron teeth

are now worked and these gather up the weeds further, which are now collected and heaped together and burnt. The 'koradu' or the levelling log is worked again in order to level and firm up the ground. Cattle manure is now spread and a smoothing harrow is now drawn to make the surface even for sowing. All these operations which are carried out with the help of the early pre-monsoon showers result in not only producing the proper tilth but in conserving the moisture for the seed bed. Seed paddy is sown invariably in rows in these tracts either through a regular four-tyned drill or through a bamboo tube (called a 'sadde') which is tied behind a plough and through which the seed is dropped in the plough furrow. The seed is covered by a light harrow. After the seeds germinate and the braids can well be made out, small interculturing bullock hoes are worked between the rows, the teeth straddling the rows. At frequent intervals again these hoes are worked and the ground kept well stirred and weeded. The heavy rains come about that time and the fields become flooded. The rice plants now grow under the usual flooded conditions. Weeding is an elaborate operation as they keep springing up all the time. The hoes are now worked in the flooded field and enormous masses of weeds are gathered for thorough removal. After this hoeing, a smoothing log called a 'neer koradu' is dragged over the crop, after which no further operations are needed until the crop matures, except to see that the field contains enough water standing to the proper depth.

(*b*) *Maidan cultivation.*—In the second method, the field is ploughed soon after the harvest of the previous crop, if possible, or with the first rains or with special irrigation to soften the ground sufficiently to admit of ploughing. The ploughings are repeated and at least four ploughings are given before the early rains set in; the weeds are removed and burnt; manure is spread and another ploughing is given and the field brought into the proper tilth. With the first good rain usually early in the month of June the seed paddy is sown broadcast and harrowed in. The crop is allowed to grow with the help of the rainfall alone, and no water is impounded until the crop is eight to ten weeks old. Water is then let in. The harrow is now worked and then three or four hand-weedings are given in the course of another six weeks. The water is kept impounded until the crop matures.

The Manuring Of Rice.

The ordinary manures and soil ameliorants used in rice cultivation are cattle manure, ashes, tank silt, and moss from drying tank beds, "rab burning" materials, green manures and manurial earths. Fish manure, oil cakes, bone-meal and artificial manures like sulphate of ammonia, ammophos, leunophos, and superphosphates are also used and their use is steadily increasing as a result of their popularisation by the Agricultural Departments. For keeping down the level of the fields suitable for

impounding water, long trenches about $1\frac{1}{2}$ to 2 feet in depth and about the same width are dug in the fields in regular strips and most of the earth especially from the lower portion or sub-soil is carted away and the fields are then levelled. Although this cannot in any way be called an addition of manure, the improvement effected is remarkable and in the succeeding standing crop of rice the strips which were dug can be easily picked out by the strikingly better growth and the dark colour of the crop thereon in contrast with that on the undug strips. Where there has been "alkali" accumulation, much new soil is carted into the field which more or less dilutes the strength of the alkali and renders it less harmful. Considerable silt from irrigation tanks is removed when the tanks dry up and is carted on to rice fields and in some places is about the only material added as manure. Similarly from tank beds which are quite or almost dry a great deal of the moss and water-weeds is also removed and added to rice fields. The silt from many water channels has however to be carefully avoided as this generally contains the seeds and roots of sedges and reeds which sprout in the rice fields and become very troublesome weeds. In old abandoned village sites, around old forts, and some special situations, an ashy coloured earth called "boodi mannu" or ashy earth is to be obtained and this is largely used as a manure both for dry and wet crops. It generally contains bits of bones, ashes, potsherds, 'kunkar' nodules and so on, which are probably the remains of old village refuse heaps, the sites of ancient battlefields or abandoned village sites.

In certain tracts, notably in the eastern parts of Mysore, the penning of sheep is a common practice and the penning of 1,000 sheep per acre per night is usual. Nursery beds may receive sheep manure even at a higher rate.

The burning of "rab" is a manurial practice peculiar to the tracts of heavy rainfall in Konkan in Southern Bombay. Dried cowdung cakes and dry leaves and branches of certain trees are put up in piles in different parts of the field together with the stubble and scrapings of the field itself and these piles are lighted and made to burn slowly. After the materials are burnt completely, the ashes and burnt earth are spread uniformly over the field. For nursery beds of rice especially this practice is invariably adopted. Fields thus treated with "rab" manure are found to yield a better crop of rice than those not so treated.

A practice very similar to the above is the shifting cultivation carried on by jungle tribes called "Kumri" cultivation in Mysore. Patches of jungle are burnt down and in the stirred earth and ashes, rice is sown in the early showers and often bumper crops are said to result. The land is abandoned after two or three crops are taken and a new piece is taken up and treated in the same manner. The practice has been stopped almost completely on account of its destructive effect on the

forest and is kept up only where a young plantation of teak or other valuable timber is to be raised later on.

Cattle manure and ashes of all kinds generally mixed together form the commonest manure and are applied to the extent possible. Except nursery beds which are everywhere liberally manured in this way, it is only in villages where the main crop is rice that cattle manure is applied to rice fields to any large extent. In villages where both rice and dry crops are cultivated, rice fields generally do not receive any cattle manure, which all goes to the dry crop fields. Rice fields in sections where the cultivation is really of a high order are manured well, but elsewhere either none is given at all or about five cart-loads per acre are applied.

Green manure in rice cultivation.—In the channel areas and the large deltas where practically all the land is cultivated, very few cattle can be kept and even plough bullocks are sometimes bought at the ploughing season and sold after some months. Cattle manure in these tracts cannot be therefore obtained and the use of green manures is largely resorted to. The use of green manures is so striking and almost universal a feature of rice cultivation that this subject of manuring assumes peculiar importance.

Green manure is applied either in the shape of leaves and twigs cut and brought from outside to be ploughed in or in the shape of crops specially grown in the fields in which it is to be used. To the former class belong 'Honge' (Pongamia glabra), 'thangadi' (Cassia auriculata), 'Yekka' (Calatropis gigantea), Neem (Melia azhadirachta), the creeper 'Ugani hambu' (Pettsonia spp.), wild indigo (Tephrosia purpurea)—which may be put down in both classes as it is sometimes grown for green manure and sometimes collected from the jungle and brought in—and a number of other kinds of vegetation such as the 'portia' (Thespesia populnea), 'four o'clock plant' (Mirabilis jalapa), etc. To the second class belong a number of leguminous crops like the pulses, greengram, horsegram, blackgram, and cowpeas and other legumes like sunnhemp, daincha and wild indigo. The action of these green manures appears to be two-fold, *viz.*, both an improvement of the physical condition of the soil and helping aeration and drainage and a direct addition of plant food material. Action in other directions is also possible, especially such as may result from any of the active principles peculiar to particular green manure leaves or other properties. It is the common belief that some of these leaves have special virtues. The 'honge', for example is a highly esteemed tree of this kind. Neem and Calotropis are specially believed useful on alkaline soils and the former perhaps as a repellant against insect pests as well.

The exact method of action of the green manure is not definitely established. Their role as at present known is to increase the production of oxygen through the agency of a film

of algæ usually present in rice fields. These act upon the carbon dioxide which is produced directly and by the oxidation of the marsh gas produced in the fermentation of the green manure; the oxygen set free is used up to help the aeration of the roots of the rice plants and the carbon is taken up by the algæ themselves for their growth. The most valuable plant food, *viz.*, Nitrogen, of these green leafy manures is given off as gas and escapes into the air so that according to present investigations the benefit to the rice crop is not through the addition of nitrogen as a plant food to the soil but only indirectly through helping the plants to take up and assimilate what remains in the soil more fully than otherwise. It is somewhat difficult to reconcile this view with the remarkable effect of green manures in raising the yields of rice which one would ordinarily attribute to increased plant food in the soil. It must be noted, however, that where 'Honge' and 'Thangadi' are used as green manures they consist of a good deal of woody twigs and branches; after the rice is harvested these branches are seen to remain very little changed and it is usual to gather them for fuel. Even the leaves remain either as skeletons of the cellulose frame-work or only partially decayed, many being almost intact except for being blackened or browned; all these observations lend some support to the view that the action is not of the kind usually associated with the ordinary manures. In certain tracts rice is never grown unless 'honge' manuring is given. Many cultivators in these tracts own plantations of 'honge' trees which are systematically pollarded for furnishing 'honge' leaf manure.

The second class of green manures, *viz.*, those grown in the field in which they are to be ploughed in, are almost invariably legumes—a class of plants which enrich the soil in which they grow in nitrogen gathered from the air through the agency of the bacteria in their root nodules. The cultivation of these crops is separately dealt with, and here some of their special characteristics as green manures may be referred to. They are all quick growing crops and are adapted for growing within the short period of two or three months preceding the cultivation of rice, taking advantage of the early showers. The pulses yield a moderate crop and where they can be grown to maturity during this period, the pods can be gathered and the leaves and stems ploughed in as green manure. Both the pulse crops and some others like sunnhemp are eaten by cattle, they can therefore be partially grazed down, and what is left may be ploughed in. The same advantage acts also as a drawback, for they have to be protected from stray cattle, especially when only a few cultivators grow the crop and others leave their fields fallow. In this case the fields will have to be fenced or guarded or leguminous crops which cattle do not graze will have to be grown. Crotalaria striata, 'daincha' and wild indigo belong to this class, though

with nitrate manuring. This is, however, exceptional and nitrogenous manuring (with artificial manures) for rice is to be in the shape of ammonium compounds or as calcium cyanamide or urea (floranalid) which easily become converted into ammonium compounds in the moist soil. Very large doses of artificial manures neither produce any large response nor are they found profitable financially; as a matter of fact even moderate doses result in a loss as the manures are costly and the produce cheap. The best combination can be stated to be as big a dose of green manure as can be managed, supplemented with a mixture of one cwt. of sulphate of ammonia and 1½ cwts. of superphosphate per acre. The mixture of the last two materials can be replaced by the combined fertiliser Ammophos or Leunophos. There are however several grades of these which differ both in the actual quantities of the nitrogen and phosphoric acid but also in their proportion; and in each such case the quantity required will have to be calculated so as to furnish about 18 to 20 lbs. of nitrogen and about 30 lbs. of phosphoric acid per acre.

The mixture will have to be applied at or about a few days before transplanting; backward crops may later be pushed forward by an additional small dose at the last weeding.

Rice is said to be heavily manured with artificial manures in Spain, which, combined with the ample and regular irrigation accounts for the very high yields of rice in that country. The usual dose given is 600 to 800 lbs. per acre of a mixture containing 40 per cent sulphate of ammonia, 54 per cent superphosphates and 6 per cent sulphate of potash.

As regards the utilisation of nitrogen and phosphoric acid from manures, it has been found (in Ceylon) that only from 20 to 25 per cent of the phosphoric acid applied in the shape of manure is absorbed and that much of the remainder passes into the insoluble form in the soil. Nitrogen is absorbed almost completely from soluble manures like ammonium salts, whereas only about two-thirds is absorbed from insoluble forms like green manures. In the mature crop the grain contains 71 per cent of the nitrogen and 82 per cent of the phosphoric acid of the whole crop, while the straw contains 86 per cent of the lime and 78 per cent of the potash.

Rotations for Rice.—The conditions under which rice is grown are in many cases such that no other crops can be grown under the same conditions, and therefore no rotation of crops is possible. Thus in the tracts of very heavy rainfall such as the Malnads, in the low coastal belts liable to inundation and partial submergence of crop, in low-lying fields where water collects and stands for many days, in undulating tracts with terraced fields where water has to be continually flowing down the slope and again in the vast deltaic and other tracts where the universal cultivation of rice makes the soil too wet for other crops to be grown alongside, rice is the only crop that can be

grown. Moreover as the water is available only during a season of about six months whether under channel irrigation or under natural rainfall, the soil is dry during the remaining part of the year and has to be left fallow. So that in all these cases it may be said that rice follows rice without any rotation, with only an intermediate fallow as an enforced virtue. This fallow may be either ploughed or bare.

Regular rotation is practised where water is available in more than one season, *i.e.*, under (1) the large tanks either rainfed or fed by channels from rivers, (2) the great storage reservoirs with their assured supply for several years and (3) under irrigation by wells either independent or supplementary to tank irrigation. In large stretches of rice land such as (2), rotation is rendered possible and also facilitated by the block system of irrigation, by which the land is all divided into blocks each of which grows a different crop, one of them being rice.

Rotations for rice under the abovementioned different conditions comprise the following :—(1) Rice from November or December to May or June, followed by ragi or jola as a monsoon crop from July-August to October-November. (2) Rice from June-July to November-December followed by sugarcane in the next year. (3) More intensively, a vegetable crop may intervene between the sugarcane and the succeeding rice crop in the above rotation. (4) Rice once in the course of three or four or even five years, during which latter period crops either single like plantains or betel leaves or a series of crops like turmeric, chillies, tobacco, irrigated cotton, groundnuts, irrigated ragi, jola and so on occupy the land. These rotations are further dealt with under the respective crops. In the channel-fed and other areas, the system of growing a catch crop like one of the pulses prevails serving somewhat the purpose of a rotation crop.

It may be noted in this connection that a rather unique rotation for rice is practised in Italy. Rice is rotated with fodder grasses and clovers, which occupy the ground for two or more seasons, during which the fields are treated as meadows and pastures. The system forms part of a mixed husbandry, with rice cultivation combined with dairy farming.

Botany and Varieties.—Rice—*Oryza sativa*—belongs to the natural order Gramineæ and is an annual tufted aquatic grass. The root system is fibrous and generally consists of two whorls, one a primary set developing from the radicle itself and the other a secondary set which is permanent and which springs from the first node of the plumule and is situated higher and almost at the surface. From the same spot successive whorls of roots develop which though they appear to spring from one node are really derived from separate nodes which are so close together as to appear one and the same node. Though the roots develop under water, rice roots are not aquatic and require considerable æration

for proper development. The root system is not deep or wide-spread but is very profuse. Planted wide the plants tiller freely and these tillers nearly always spring from the bottom node near the surface of the soil but occasionally branching may occur from a node higher up also. The leaves are many, rather rough, thin and lanceolate in shape. The stems are hollow, cylindrical and begin to show after the tillering of the plants ceases and develop rapidly as the flowering time approaches, the upper internodes being considerably and successively longer than ones below. The flowering begins usually in a definite interval of time from sowing irrespective of the date when the plant was transplanted. The inflorescence is a loose panicle highly branched and nearly always drooping with the weight of the seeds. It is formed by the continuation of the stem and the branches spring in whorls or singly from nodes on the rachis or stem of the panicle. The flowers themselves are borne at the ends of the branches. The glumes are four in number, the first and second are minute, (except in the so-called 'winged' varieties), the third and fourth subequal, the former sometimes bearing an awn either long or short. The colour of the glumes in the ripe seeds is varied, very light yellow to golden yellow, yellowish brown, deep brown, deep purple or black, and the surface is smooth or markedly grooved or ribbed. The stamens are six in number. The stigmas are two and are feathery. These feathery stigmas are either white or coloured light purple; this latter is the case in all varieties in which the husk of the grain is coloured. The rice plant is usually self-fertilised but to a small extent cross-fertilisation also takes place. Depending upon the variety and weather conditions such cross-fertilisation may go up to even 20 per cent though anything above 5 per cent should be considered unusual.

The ripe grain can sprout without a period of dormancy but it cannot be definitely stated whether crops raised from such freshly gathered grain can yield crops equal in growth and yield of produce to crops raised in the normal way, *i.e.*, from older grain. Moreover, though the husking of the grain results in the removal of the embryo and therefore only the unhusked grain or paddy has to be used for sowing, still it is possible to remove the husk in such a way that the embryo remains adhering to the endosperm; such husked grain will sprout and can be sown for experimental purposes. Husking in a wooden husking mill will yield a fair percentage of husked grain with the embryo intact and in the case of some varieties this percentage will be considerable.

The varieties of rice in cultivation are very large in number and run into hundreds. It is possible that a good many which are known by different names—mostly local— are really one and the same, but even making allowance for this fact, rice is unique in respect of the very large number of varieties. The varieties

are sharply divided by various characters, and can be classified in many ways. They can be classified into upland rices which are suited to dry or unirrigated conditions and rices for irrigated or flooded conditions; among the latter there are the ordinary irrigated rices, the rices which can grow in or withstand considerable flooding up to four or five feet of water and others which can grow in even twenty feet of water. There are rices for the ordinary soils and there are rices for the salty coastal flats and again for alkaline soils. Some of the 'aman' varieties of Bengal are examples of the deep water rices. A variety grown in the Tanjore District and called Vadan Samba and some Malabar varieties called Bali, Ozkayama, Orkuttadan are examples of the latter kind. Rices can be divided according to the length of the growing period such as short, medium and long season rices. They can be divided according to the season to which they are suited. They can be divided according to the quality of the starch in them, into glutinous rices and the non-glutinous rices; the former are sticky and "glutinous" when cooked, unlike the ordinary rices in which the cooked rice grains fall apart and are mealy to eat. There are the trade distinctions of coarse, medium and fine rices which are descriptive of the shape and size of the rice grain, both paddy and rice. There are again the red and white rices, classified according to the colour of the husked rice grain. There are the outward characters of colour, thickness, shape, length and breadth, in all of which the gradations are almost innumerable. The colours are black, smoky, golden, yellow, yellowish brown, chrome yellow, light and deep brown; in shape the grains are thin and long or thick and almost rounded, and medium; the thin and long grains break in the process of hulling and yield an undue proportion of broken rice while the thick, short and rounded grains hull and polish with the least proportion of broken grains. The plants in the field too show marked difference in the height of growth, in the tillering capacity, in the strength of the stems, in the size of the panicles and the number of grains therein, in their liability to shed their grain, in the proportion of grain to straw, in the yielding capacity, in the proportion of rice to paddy and so on. In a large number of varieties the grains possess awns; these are very long in some and small in others and rudimentary in still others. In some varieties the paleæ at the base of the grains are so much developed that they resemble wings, and the grains are accordingly described as 'winged'.

A descriptive list of the large number of varieties grown in Mysore has probably never been attempted, certainly not on the basis of actual cultivation trials of the different varieties and it will be impossible even to catalogue them comprehensively. Examples only of varieties coming within one or more of the several classes mentioned among the varietal characteristics will be given.

Among the early varieties which take about 150 days from seed to harvest are: *Bangarkaddi, Yelandur Sanna, Bilidappa, Kapile Sanna, Krishna Neela, Chintamani Sanna, Halubbalu, Hassan Doddi, Kavade Doddi, Dabbinasale* (early type), *Garki Sanna, Giddabyra.* Among medium varieties which take above 150 days up to 170 days are *Banku, Alur Sanna, Budanur Sanna Dabban Sale, Bolumallige, Gunasale, Kesari Bhatta, Nagapur Fine, Chandragutti,* and *Hasadi.*

Among late varieties maturing between 170 days and 200 days and over are *Kembuti, Kaddi, Patsomanahalli, Dodbili, Dodbyra, Maralkanti, Walya, Jeddu, Hegge, Jolaga, Togarina, Siddasale, Somasale, Hosalli Bili.*

One and the same variety takes a longer period to come to harvest when it is sown dry in the early rains as in the Malnad than when it is sown in a nursery and then transplanted. In respect of twelve varieties which were cultivated in both these two methods, the difference in time varied from 15 days in some varieties up to fully one month in others, the earliness being invariably in favour of the transplanting method.

Classified according to the seasons to which the varieties are suited the following belong to the main or rainy season :—

Kaddi	Kembuti	Patsomanahalli	Dabbansale
Bolumallige	Maralakanti	Dodbili	Alur sanna
Gamsale	Siddasale	Garike sanna	Banku
Kesaribhatta	Nagpur fine	Halubbalu	Togarina
G.E.B. 24	Walya	Jeddu	Krishna Neela
Bhave	Hassan bili	Jeerge sanna	
Bangarkaddi	Dodbyra		

The following belong to the Vaisak or summer season :—

Chintamani sanna	Budame sanna	Halubbalu
Gidda Byra	Candragutti sanna	Puttu bhatta
Kavade doddi	Alur sanna	Hassan doddi
Three months' rice	Two months' rice	Bangarkaddi

It will be noticed that there are several varieties which appear in both groups. These can be grown in both seasons.

While all the varieties listed above are suited only to irrigated cultivation, there are also varieties which can be grown like dry crops under ordinary rainfall or in moist situations. These are Maradagana bhatta, Mullu bhatta, Salu bhatta. These are all coarse grained and give red rices. Maralkanti, Doddabyra, Walya, Jolaga, Jeddu are coarse grained and give red rices.

The red coat of the rice grain is seldom so persistent as not to be removed in the processes of husking and polishing; it is only in the glutinous black rices that the black or deep purple pigment extends somewhat deep and even in these the tint diminishes towards the centre of the grain where a white core is distinctly made out. Although generally it is only in the coarse grains that the rice is red, there are several varieties among the finer kinds also where the rice grain is red. Banku is an instance in which there are both red and white grains though the paddy is identical in both cases. In Halubbalu also

two such kinds can be distinguished though the paddy looks alike in both cases.

Fine rices of the red coloured kinds are fancied as more tasteful than the white sort of the same variety and fetch a better price in certain markets; this premium has opened the door to fraud in which the white kinds are coloured artificially to resemble the red grain and sold. The colour however, goes off when the rice is washed before cooking. In the well-irrigated sections of the eastern taluks of Mysore especially this practice prevails.

In the case of par-boiled rices the red colour becomes somewhat firmer during the process of parboiling and the pigment appears to penetrate or diffuse into the grain. The red colour is therefore not so easily removed in husking as in the case of the same grain when husked raw.

All the varieties in the list which are called "sanna" belong to the class of fine grained rices while the others are medium to coarse. The length of the grains and their thickness across the middle will give some idea of the sizes of these grains. These measurements were made for some of the Mysore grown varieties of rice by noting the number of grains that can be laid end to end in a six inch length and again the number that can be laid in the same six inch if placed in a line side by side together; the former figure gives an idea of the length of the grains and the latter of its thickness. These figures are as below :—

Name of variety.		*No. of grains along.*	*No. across.*
Chintamani sanna	...	17	67
G. E. B. 24	...	21	66
Kaddi	...	19	53
Alur sanna	...	18	61
Putta Bhatta	...	26	55
Gidda Byra	...	20	52
Hasadi	...	18	50
Jeerige sanna	...	27	61
Bolumallige	...	20	50
Banku	...	14	62
Sidda sale	...	20	47
Halubbalu	...	20	54
Bangarkaddi	...	20	60
Walya	...	20	49
Doddi	...	19	48
Hassan Bili	...	20	52
Budume Sanna	...	19	46

It need hardly be pointed out of course that the smaller the number in the two columns the longer and thicker it is, and the larger the number, then the shorter and thinner it is. Banku for instance is the longest grain in the list, the 'jeerge sanna' the shortest. Both are also thin grains but Chintamani sanna and G. E. B. 24 are thinner still.

An important economic character in which varieties differ is the liability to shed their grains. In rices the grains break off from their rachis very readily, but varieties differ in the degree to which they show this character. The more readily a variety sheds its grain the greater is the loss of grain in the field or on the way to the threshing floor; some varieties are very bad in this respect, while others are either only moderately so or more or less hard to thresh. Some of the good varieties which are grown in the Vaisak or hot season are very prone to shed, and this greatly neutralises the other advantage they possess such as earliness of season and fineness of grain. Banku, Yelandur sanna, Kempu sanna, Krishna neela are among the ones which shed badly. The long season and medium season varieties grown in the rainy season are more satisfactory in this respect. It must be stated that the trouble with excessive shedding can be greatly overcome by harvesting the crop a little earlier than dead ripe and stacking it so that it completes its ripening in the stack. It is usually in the dead ripe stage that the grains shed badly, even the varieties usually considered non-shedding not being altogether exempt at this stage.

It is an interesting fact that the "wild" rice which is known by the name of "Nere or Mere bhatta" in the Shimoga District and which is a most troublesome weed to deal with, sheds all its grains as they ripen. This is the very feature which makes its removal as a weed very difficult because so much seed is shed from the plants which escape removal that they sprout in great numbers in the succeeding crop of rice. The permanent removal of this weed is almost impossible, and at every cropping season huge quantities have to be pulled out at weeding time.

The nature of the straw and its quantity in proportion to the grains are also important characters which differentiate varieties. While in foreign countries varieties mostly have stiff and strong stems which enable them to stand erect permitting thereby the use of harvesting machinery, the Indian rices are nearly all of them weak and thin with the result that they lodge badly when the grains are ripening and lie almost flat on the field. Careful harvesting with hand tools alone is possible. The use of machinery of course is ruled out, even otherwise on account of the small sizes of the fields and uneven surface. The straw of most varieties does not possess the strength, moreover, for being used for the making of baskets, hats, etc., for which rice straw is made use of in Japan. As an important fodder for cattle and in fact as the sole fodder in many tracts, the quantity of straw obtainable per acre is important in this country. Some varieties which are good yielders of grain suffer from the drawback of being low in respect of straw. The popular variety G. E. B. 24 is an example of this kind. There is much difference between varieties in this respect as the following examples will show.

SUMMER CROP 1928-29 (HEBBAL FARM, MYSORE).

Name of variety		*Grain* (*in lbs. per acre*)	*Straw* (*in lbs. per acre*)
Chintamani sanna	...	1,663	3,333
Budume sanna	...	1,820	2,430
Halubbalu	...	1,700	2,470
Gidda Byra	...	1,595	2,850
Chandragutti	...	2,425	3,580
Putta Bhatta	...	1,695	3,120
Kavade Bhatta	...	2,150	2,940
Garike sanna	...	2,065	2,300
Alur sanna	...	1,220	3,580
Bangarukaddi	...	1,420	1,760
Banku (rainy season 1925-26)	...	1,540	1,700
G. E. B. 24 Do	...	1,900	1,540

Harvesting and Threshing.—The harvesting of rice commences as soon as the field dries somewhat after draining off the water and becomes fit enough for the labourers to walk about. Harvest is generally begun when the grain is quite ripe, but there is much to be said in favour of harvesting at an earlier stage and allowing the completion of the ripening to take place in the stack. After the crop is harvested it is allowed to lie on the fields for some time up to three days, and then brought over to the threshing floor. The threshing is taken up immediately after or the sheaves are put up in stack and taken up for threshing after about ten days when all the crop has been harvested. In the malnad districts of Mysore it is usual to keep the stack for six to eight weeks and take up threshing only thereafter. The threshing is carried out by beating the earheads on an inclined plank or a bench or a stone; the grains separate with great ease though in many cases a small proportion is left over in the straw. This is all laid aside and after the first threshing by beating is all over, the straw is taken up for a fresh threshing to get the grain that has been left over. This second threshing is by means of trampling out the grain under the feet of cattle. In certain sections the grain is threshed out only by this latter process and no preliminary beating out of the grain is done. In the malnad—especially in the Shimoga District — the threshing is done under a stone roller, which is about 2½ feet long and 2 feet in diameter. This method is speedier and more convenient than the threshing under the feet of oxen.

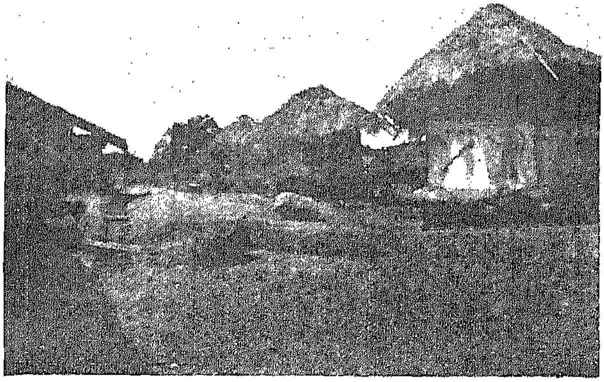
Winnowing and cleaning the grain.—The grain is now winnowed to remove chaff or empty grains of which all bulk grains always contain more or less. Empty grains are produced as the result of the flowers of the rice not having been fertilised owing to a spell of cold weather or to a shower of rain having interfered with the fertilisation. The pollen is not shed in the former case at the proper time and in the latter case it is washed off, either of which results in the grain not setting. Birds attack the

grain in the 'milk' stage and suck the contents, leaving the grains empty. Pests and diseases dry up the panicle in whole or part, before grains can mature, which also results in empty grains. The winnowing is done by pouring the grain out of a basket or tray held overhead and letting the wind blow off the chaff and dust as the grain falls on to the floor, and further by frequently fanning the heap on the ground vigorously. The heavy grain collects straight below the winnowing tray while the chaff and the lighter grains around the periphery of the heap, far or near according as they are quite or partially empty, and are swept aside.

A lot of clay particles, coarse sand and grit and the seeds of certain water grasses get mixed with the paddy and these have to be separated out by sieving, although even then the paddy cannot altogether be freed from them which persist even after the paddy is husked; this is especially the case with the weed seeds and the coarse quartz grit of the Mysore Channel tracts. The paddy is put through small circular bamboo sieves or large rectangular sieves of bamboo or sheet iron which are slung and rocked to and fro cradle-fashion. For seed purposes grain is gathered from the portion right under the winnowing tray as this is the heaviest grain; it is thoroughly cleaned and dried in the sun and then stored.

Yields.—The yield of paddy per acre varies a great deal with the varieties and the season in which they are grown, not to speak of the soil, manuring, irrigation and general excellence of the cultivation. In Mysore the highest yields are obtained in the eastern taluks under well-irrigation, the next in order come the great tank-fed areas of Kolar, Tumkur and Bangalore, the channel tracts of Mysore come third and the pure rain-fed crops of the Malnad come last. The highest yields may go up to even 5,000 lbs., but in the best tracts of Mysore about 4,000 lbs., of paddy are easily obtained. On fertile tank-irrigated lands 3,500 lbs., are usually expected, while in the channel areas the yields may be put down between 2,000 and 2,500 lbs., and in the Malnad tracts at about 1,700 to 1,900 lbs., per acre. The world's highest yields are reported from Spain where the yield reaches 6,000 lbs., of paddy and followed closely by Japan with about 5,000 lbs. The latter is on small scale intensive farming with the plants manured and cared for almost individually, but the former is in large scale farming and is attributed chiefly to the heavy manuring with artificial manures with an abundant and well-regulated water supply.

Storage.—The grain is stored only in the unhusked condition as paddy and for this purpose, has to be well dried before being put in storage. Between the weight as harvested and the weight after drying for storage there is considerable difference and this loss of weight will amount to 10 or 15 per cent on the fresh weight. Many kinds of storage and storage receptacles

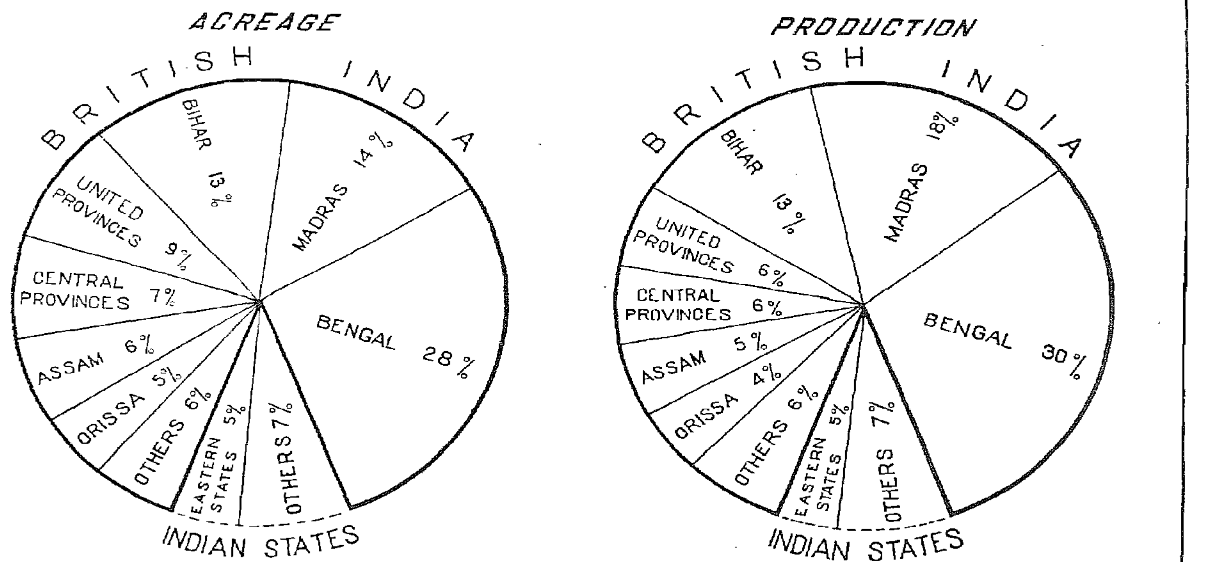


Rice granaries made of bamboo work plastered over with mud and erected along the middle of the village street, Shimoga District, Mysore State. [Photo by author.

Rice Granary called 'Pattarai', Madras Presidency.
[From the Report on the Marketing of Rice.

SHARE OF DIFFERENT PROVINCES & STATES IN ACREAGE & PRODUCTION OF RICE IN INDIA.

AVERAGE
1927-28/1936-37



[From the Report on the Marketing of Rice.

can be seen; thus the grain is merely heaped in large rooms well protected from sparrows and vermin. Tall circular wicker bins well-plastered over with mud are erected on elevated platforms and into these the grain is filled, covered and plastered over. Substantial wooden stores made of heavy planks like huge boxes with legs which clear the bottoms well above the ground, and covered with flat heavy wooden planks with a trap door for pouring in the grain and with an aperture for drawing off the paddy near the floor of the structure are common in the better class households of the Malnad. Circular brick work structures like silo towers can also be seen, while elaborate brick work granaries which look like elevator bins, constructed in pairs with a flight of steps dividing them and serving them both for carrying up the grain and protected by a substantial roof can also be seen with the large landlords. Galvanised iron structures, small and large and rectangular or circular in shape, are of recent introduction and are found convenient to look after and to keep clean. They have the further advantage that the paddy in storage in them does not absorb moisture in the rainy season even in the heavy rainfall districts of the Malnad. Damp is a serious trouble to guard against and in the larger stores such as those belonging to Grain Banks which have to hold paddy in storage for many months, much paddy in contact with the floor and walls becomes mouldy and is ruined. Floors will have to be elevated on pillars to clear the ground and the walls well protected by projecting eaves against the rain. The ravages of bandicoots is another serious trouble and unless the floors and the lower portions of the walls are of hard concrete and reinforced with iron materials like close-meshed expanded metal, these animals can burrow under and through the floor and do great damage. The storage moth is another pest; clean smooth walls and rounded corners will afford less lodgement to this pest, although cleaning every time the bin is emptied is one of the chief means of keeping out this pest. This is further referred to under 'rice pests.' The storage of paddy greatly improves the cooking quality of the rices. Fresh and new rice is difficult to cook in the proper way and gets generally into a pasty condition, whereas rice from paddy stored for about six months or more cooks in the usual way. The fresh rice contains an active enzyme 'a—amylase' which passes into a dormant stage after a certain period of storage. The starch in the rice also appears to be altered in some way by storage, as it is found that the starch of the old rice is more easily digested than the starch of the new rice.

Husking Paddy.—Rice for consumption is prepared by husking or 'hulling' the paddy either raw or after partially boiling it in water; the latter is generally referred to as 'parboiled' rice. The husking is performed by pounding with iron-shod wooden pestles in a stone or wooden mortar by hand. The

pestle may form one arm of a wooden lever mounted on a stout short piece of timber fixed near the mortar in the ground, which is lifted and dropped by applying pressure on the other end of the lever. This is managed by pressing the end of the lever with the foot and removing it alternately; or by the coolie jumping on and off alternately from this end. Paddy is also husked by putting it through a wooden grinding mill somewhat like the domestic grinding stone mill. The two halves are each about nine inches high and 27 inches in diameter, and the husking surface is grooved closely about half inch wide and herring-bone-fashion. As the wood wears new grooves are cut and this is repeated until the sections become too reduced in thickness to be of use. All these methods have however largely given place to rice hulling by machinery and these rice mills are studded all over the rice growing tracts and may be said to handle practically the whole of the produce. In these mills, especially the larger establishments, the paddy is cleaned and hulled and the whole rice, separated from the broken rice and bran, is also more or less polished. In the hand-pounded rice considerable bran still adheres to the rice and this certainly increases its nutritive value; in the machine milled rice this layer of bran is removed almost entirely and in foreign countries the rice is further polished and glazed by the use of talc powder which has to be washed and removed before the rice is used for cooking.

Raw and parboiled rice.—Raw rice is the form in which rice is largely consumed, by the higher classes alone in certain districts but elsewhere by everybody. In South India the custom is to 'parboil' the paddy; the poorer classes invariably eat only 'parboiled' rice and the upper classes consume it either as raw rice or 'parboiled' rice. In the Tamil districts and in Malabar the custom is for nearly everyone to eat rice only as 'parboiled' rice.

In the parboiling of rice part of the constituents of the layer between the husk and the rice kernel pass into the body of the kernels. The total nitrogen of the rice increases therefore by parboiling, as compared with raw rices. The percentage of phosphates however remains unaffected. With the same degree of milling, parboiled rice is richer in nitrogen and phosphates than raw rice. Furthermore whether polished or unpolished parboiled rice loses less nitrogen and phosphates than comparable samples for raw rice and similarly less of water soluble constituents pass into the 'cunjee' (or the liquid portion of cooked rice) in the case of parboiled rice.

Quantity of irrigation water for rice.—The duty of water for rice is taken at varying figures depending upon the duration of the crop, nature of the rainfall, the aspect of the country and on the source of the irrigation, whether from tanks or river channels drawn from rivers. The duty varies from 50 acres to 100 acres which is the figure expressing the number

of acres that can be irrigated by a flow of one cusec, through the growing period. The average for tank irrigation may be taken as 70 acres.

Certain experiments to find out if the use of water can be economised without detriment to the yield were conducted on the Hebbal Farm, Mysore. Comparisons were made of irrigation given once in 3 days, once in 5 days and as often as may be necessary which meant in practice continuous irrigation. They were conducted both in respect of a summer and of a rainy season crop. The quantity of irrigation water in acre-inches required to grow a crop of rice is of course a variable figure as it will depend upon the season, the duration of the crop, and the nature of the soil. The following figures relating to the quantities of water used give an idea of the requirements of rice in acre-inches. The water was in each case measured exactly as it was let out from cisterns of definitely measured capacities. The rice fields of the Farm are tank irrigated and flat and the soil a black clayey loam. The irrigation period varied from 100 to 130 days from transplanting to harvesting and the quantity of water in the different treatments varied as shown below.—

	Rainy season crop		Summer crop	
	No. of irrigations	Acre-inches including rainfall	No. of irrigations	Acre-inches including rainfall
Irrigated whenever necessary ...	53	158	48	135
Irrigated every three days ..	34	106	28	92.5
Irrigated every five days ..	19	65·3	20	62.5

Note.—There was a rainfall of 13'42 inches for the rainy season crop and of 6'92 in the summer crop.

The yield of grain was certainly reduced by reducing the number of irrigations, but the difference between the three days interval and the five days interval was neither large nor consistent, as shown below :—

	Grain per acre in lbs	
	Rainy season	Summer
Irrigated as often as necessary, ...	1920	3610
Irrigated once in three days ...	1640	3230
Irrigated once in five days ...	1680	3210

Pests and Diseases.—The insect pests of rice comprise those which attack the growing crop and those which attack the stored produce, whether paddy or rice. Among the insect

pests of the growing crop, some are serious in the nursery and the young transplanted crop, others during the period prior to the heading out of the crop and still others when the crop is fully in earheads.

In the western parts of Mysore the rice grass-hopper—*Hiero glyphus banian, Tel.*—is the most serious pest of the young crop, the leaves being completely eaten off and the crop seriously damaged if not ruined, necessitating a resowing or transplanting. Prior to getting into the rice fields the young hoppers live on the grass growing on the dividing bunds of the rice fields. The remedy is to drag a grass-hopper trap bag over the affected field and kill the hoppers which fall into the bag in hundreds. In the summer the field bunds are scraped and dug to expose and kill the egg masses. By this means a great reduction is effected in the brood which may emerge during the following crop season.

The rice case worm (*Nymphula depunctalis*) is another pest of the young crop, especially after transplantation. The grubs of this insect eat the green chlorophyll of the leaves and reduce them to whitish skeletons justifying the name 'Kokkare roga' (which literally means the 'crane disease') which is given to it in Mysore. Bits of the leaf are cut off and rolled round into thin cylindrical rolls of about one or one and a half inches in length and the larvæ shelter themselves in these rolled up bits of leaf and float on the surface of the water in the field. A simple remedy is to spread a thin film of kerosine oil on the water by keeping a rag soaked in kerosine at the opening through which water is let into the plot and retain this film for a day; the larvæ are killed by this process and are then swept aside and removed.

The beetle pest (*Leptispa pygmoea*) is a serious pest in some years on the young crop in the Malnad districts. No suitable control measure has been worked out.

The rice hispa (*Hispa armigera*) is another beetle pest of the young crop; the grubs are leaf miners and eat the green matter under the epidermis of the leaves. The adult beetles also damage the leaves. In the nursery stage the spreading of a film of kerosine oil over the water in the plot and sweeping up the larvæ is recommended to rid the field of the larvæ, while in the adult stage the beetles have to be caught in hand-nets and destroyed. When the pest gets on to the transplanted field it is too widespread to be tackled in this way and no satisfactory remedy has been worked out.

The 'army worm' of rice—*Spodoptera maurita*—is a caterpillar pest which is very destructive to the young crop. They appear in enormous numbers, and work from field to field, leaving a wake of complete destruction of the young crops. No satisfactory remedies have been worked out, but on a small scale the progress of the caterpillars from field to field can be prevented

by digging trenches across the line of march, by flooding the field and sweeping the caterpillars up and, as a preventive, by cleaning up the field bunds and destroying egg masses.

The 'stem borer'.—*Schoenobius incertellus*—is a pest attacking the crop at a later stage though the young crops are also known to be attacked sometimes. The grub bores into the stem and kills the shoot, the commonest outward sign being the drying up of the young earhead which shows white in the midst of the crop. The simplest remedy is the use of light traps. The moths are attracted in large numbers and perish; as a large number of female moths, both before oviposition and after, are attracted to the trap, this remedy is fairly effective in preventing the increase of the pest and, if carried out at an early stage, will be a very good means of control.

The 'rice bug'.—*Leptocorisa acuta*—is a pest which attacks the crop at the earhead stage. The bugs suck the juice of the young earheads with the result that the grains do not develop or develop only partially. Remedies applicable on a field scale are not known.

The 'rice gallfly'.—*Pachydiplosis oryzæ*—gives rise to the curious malformation of the earhead called 'silver shoot'. Instead of the familiar branching panicle of rice, a stiff thin cylindrical growth ashy white in colour emerges in which the young grains appear as though they were glued together. The maggots of the fly bore into the stem and attack the shoot on which they produce this growth as the 'gall', which comes out in the place of the normal earhead. In nature the pest is kept in check by its parasitic enemy—a species of Polygnotus—and it is only when these diminish in number that the pest assumes any importance.

A caterpillar pest, which has not been identified, attacks the crop in almost all stages and causes much damage in Coorg. The only remedy which the cultivators have themselves devised is to kill the caterpillars at the different weedings; for this purpose the weeding coolies tie a rag or a gunny piece over their hands like a glove and squash up the caterpillars.

Fungus diseases.—Among the fungus diseases to which rice is subject, the most serious is 'paddy blast'—caused by the fungus *Piricularia orzyæ*. The disease appears on the leaves in the beginning as brown spots and streaks which gradually increase in size. Later when the earheads appear, the base of the earhead becomes affected, dries and breaks down or the glumes themselves are attacked. In either case no grain sets and the earhead contains only chaff. If however the earheads are early and the grains have passed the milk stage before the disease appears, then the loss is not so great. In an infected field the spores can remain in a viable condition even after the harvest in the stubble for as long as even six months. On such fields therefore the stubble and the underground parts should be

gathered and burnt when next the land is prepared for the succeeding crop of rice. Varieties show great difference in regard to their susceptibility to the disease. The coarse varieties and the short duration varieties are more resistant than the finer and the long duration varieties. A great predisposing cause is too luxuriant vegetative growth consequent upon heavy nitrogenous manuring. Corners of fields adjoining cattle sheds in which the drainings from the sheds flow or collect are sometimes found attacked while the others and higher parts of the field are free. One remedy lies therefore in avoiding such heavy manuring. It may be necessary to give up susceptible varieties and grow only resistant varieties.

The next disease of importance is *Helminthosporium oryzæ*. This is also characterised by small brown spots on the leaves and, when the disease is advanced, by a blackening of the nodes, the neck of the earhead and the grains. Earheads may fail to emerge at all. The fungus spreads through spores borne on the leaves, stems and grains, and the mycelium itself can lie dormant in the seed, from which the succeeding crop may be infected. The fungus attacks crops already weakened by lack of manure or other adverse conditions. Remedies lie in a change of seed from a healthy locality and in maintaining favourable conditions such as adequate manuring, cleanliness, etc.

Other diseases attacking rice are Sclerotium oryzæ, False smut or Ustilaginoidea virens, and Ephelis oryzæ but these are neither widespread nor cause any serious damage.

Chemical composition of rice.—The chemical composition of rice, both raw and parboiled, and of different kinds, is as below :

	Water	Albuminoids	Fats	Carbohydrates	Fibre	Ash
Rice ...	10·9	4·3	0·9	82·4	0·3	1·1 (Collins)
Rice ...	12·8	7·3	0·6	78·3	0·4	0·6 (Church)
Do raw, home-pounded ...	12·2	8·5	0·6	78·0	0·6	0·7 (Aykroyd)
Do raw, milled ...	13·3	6·9	0·4	79·2	...	0·5
Do parboiled and home pounded.	12·6	8·5	0·6	77·4	...	0·9
Do par-boiled and milled ...	13·3	6·4	0·4	79·1	...	0·8
Do white "puttu" glutinous	13·0	7·5	0·4	78·1	...	0·4
Do black glutinous ...	12·8	7·7	1·3	76·7	0·07	1·3

Rice is eaten in various forms. The commonest form is as boiled rice, and with the liquid portion drained away. Rice is also prepared without draining away this liquid, but this is only to a small extent. Ground up into flour and mixed with the flour of blackgram it is made up into pancakes and the steam-baked preparation called 'iddali' in South India. Mixed with the flour of other pulses it is made into numerous other dishes. Rice is prepared into a kind of puffed product like popped corn; it is also made into thin beaten flakes and in both form

is much consumed especially during travel. The composition of these latter forms is as below :—

	Water	Albuminoids	Fats	Carbohydrates	Fibre	Ash
Puffed rice ...	14·7	7·5	0·1	74·5	...	3·4 (Aykroyd)
Beaten rice ...	12·2	6·6	1·2	78·2	...	1·8 Do

Rice straw is an important fodder and in all rice growing tracts is almost the sole fodder. In the ragi-growing tracts however it is considered very poor and much less nutritious than ragi straw. Rice straw has the following composition :—Water 8·5, albuminoids 1·2, fat 1·8, carbohydrates 47·0, crude fibre 25·7 and ash 15·8 (Collins).

Production and Trade.—The total area under rice in India is 69,455,000 acres, exclusive of areas in the States, which amounts to 4,042,000 acres, making a total of 73,497,000 acres. The areas in the larger British Indian provinces are Bengal 22,200,500, Madras 10,140,831, Bombay 2,036,984, Bihar 9,512,000, United Provinces about 7,100,000, Central Provinces about 5,760,000, the Punjab about 1,100,000 and Sind about 1,100,000 acres (1937-38). The larger Indian States have the following areas: Mysore 707,670, Hyderabad 1,125,913 and Travancore 652,615 acres.

India does not grow enough rice to meet its requirements and large quantities have to be imported every year. The imports are mainly from Burma and amounted in the year 1939-40 to 3,339,338 tons of paddy (rice in husk) and 1,887,298 tons of rice valued at two crores and seventeen crores of rupees respectively. The exports amounted to 4,236 tons of paddy and 262,494 tons of rice.

The Mysore State depends to a large extent on imported rice. During the ten-year period from 1927-28, the imports have been on the average about 52,000 tons of rice, the highest being in the year 1935-36, *viz.*, about 80,000 tons.

II. RAGI (Eleusine coracana)

VERNACULAR NAMES: *Kannada*—RAGI; *Tamil*—KELVARAGU; *Telugu*—RAGALU; *Malayalam*—MUTTARI; *Hindustani*—RAGI.

Special characteristics.—Ragi is the most important grain crop of the Mysore State; it occupies more than one third of the whole cultivated area of the State, and in extent is almost equal to the area under the same crop in the Madras Province. Ragi has many valuable features which mark it off sharply from the other food grains of the world. It is one of the hardiest of the

crops suited for dry farming that can be thought of. It can grow under conditions of very low rainfall, and can withstand very severe drought, reviving again with a good shower of rain with remarkable vigour. It is a grain of great nutritive value and is considered more sustaining to people doing hard physical work than any other grain. It can be grown both as a dry crop and under irrigation. Yields under dry cultivation are much higher than from other dry-land grains and, under irrigation, high yields approaching sometimes that of rice are obtained. The crop is remarkably free from pests and diseases and the grain is likewise free from the pests and diseases which usually attack other stored grains. Ragi grain can be stored for long periods of several years up to even fifty without damage, if only it is stored in places and receptacles not subject to damp or wetting by water. Its straw is a valuable fodder greatly esteemed in the Mysore State, both for working and milking animals. Both dry-land ragi and irrigated ragi give abundant straw, although only the former is much used as fodder. The straw of the irrigated ragi is too coarse and only the soft parts are eaten by cattle.

The area under ragi in the Mysore State is about two and a quarter million acres, nearly the whole of which is grown as a dry crop. Outside of the Mysore State the crop is of some importance only in the Provinces of Madras, Bombay, Bihar, the United Provinces and the State of Hyderabad, which grow 2,600,000, 600,000, 600,000, 250,000 and 71,000 acres, respectively. Over one-third of the total area under ragi in the whole of India is situated in the Mysore State.

Rainfall.—Ragi is grown as a dry crop in regions where the rainfall ranges from 20 inches or 22 inches to 35 inches. In regions of higher rainfall such as the malnads of the Mysore State, ragi can be grown only on the uplands where water does not stand and sown or transplanted a little after the full force of the South-West monsoon is over, say, about the middle of August. Varieties are available which can withstand somewhat heavy rainfall. It is seldom however that it is grown in this way, as rice is the crop usually grown in such tracts. If the rainfall is below 20 inches or even when higher if it is concentrated in the North-East monsoon, ragi cannot be grown as a dry crop but is grown under irrigation. The yield of ragi under dry cultivation is positively correlated with the total rainfall in the five months July to November and as regards the months of rainfall in this period the correlation is with the rainfall of the two months of October and November.

Soils.—As regards soils suitable for ragi, ragi is the grain crop mainly of the red and light red, ashy coloured, loams and sandy loams. Heavy black cotton soils are not suited to ragi although on the somewhat lighter types very good crops can be seen. The practice however is to put all such black soils under jola as the main crop. Ragi does well generally on the better

class of soils, free from stone and gravel, of good depth and well prepared. Rough, stony and gravelly land is not utilised for ragi. The root system is remarkably extensive though somewhat shallow; and only good soils possess the proper texture and the moisture holding capacity required for this purpose. Ragi is however grown on somewhat clayey soils also, in fact in the same kind as is favoured for rice, with which it sometimes forms part of the rotation.

The red ragi soils of Mysore form the predominant type of soils in the Mysore State, which with some marked alterations here and there and the notable exception of the black cotton soils, form the soil cap of the Mysore plateau. They are characterised by depth and uniformity in colour and texture. They are mostly underlaid by unweathered whitish clayey material, the decomposition product of the gneisses and granites, which are the main rocks of the State. Even where light ashy coloured, somewhat sandy soils form the type, the red soils are found to underlie them as subsoils. They are all typical loams. During the rainy months, water penetrates to a depth of six feet and more and the soils may become almost saturated. The water-holding capacity is not very high and amounts to roughly 21 per cent. They retain the moisture with considerable tenacity and even when the top six inches are quite dry in the hot weather with as little as 2 per cent moisture, the lower layers retain moisture up to 12 per cent. When dry and in the hot weather they set very hard and hot weather ploughing to anything but a few inches is difficult. If however the soils are ploughed up immediately after the harvest, then moisture in the lower layers is retained up to 17 per cent as against 12 per cent in the unploughed fields. Soils under cultivation show a sharp difference between soil and subsoil in colour. The soils are highly ferruginous which accounts for their red colour; very bad types contain much fine ferruginous clay which makes them set very hard when dry and difficult of permeation for rain water and later for drainage. In chemical composition, they are characterised by a rather low content of all plant foods. The nitrogen varies from 0·028 per cent to 0·081 per cent, the phosphoric acid from traces to 0·09 per cent and the potash from 0·14 per cent to 0·47 per cent and the lime from 0·2 to 0·4 per cent. It is obvious that the soils should be considered low in fertility and good crops can be grown only with liberal manuring. The mechanical composition of some of the soils show clay ranging from 7 to 10 per cent, silt from 10·7 to 13·4 per cent, sand from 58·3 per cent to 70·4 per cent and gravel from 7·5 to 14·6 per cent.

Seasons.—Ragi is sown in more than one season. As a dry crop an early season ragi is sown in the early rains of April or early May. This is in tracts of early rainfall in the western parts of the Districts of Mysore and Hassan. This is known as

"kar" ragi and it matures about a month earlier than the main season ragi. If the early rains are not received in time or the fields are not prepared and kept ready, the sowing season is shifted forward and what is called "Yedekar" ragi is sown. Besides these two ragi sowing seasons, there is the main ragi sowing season, which normally is in the middle or early part of July, but which on account of lack of timely and sufficient rain has often to be put off till the end of August; this is the latest season for sowing dryland ragi. The types grown in this season are called "Hain", and they take a longer time to mature and are generally better yielders. Then come the irrigated ragi types. These are grown either as hot weather crops or as monsoon crops. They are both however early types. The hot weather ragi is transplanted about the month of February and the monsoon season ragi is sown like the Kar and Yedekar ragi in the early season rains. Such ragi is raised on rice land, as a quick growing grain crop and is followed by a crop of rice itself. It is also cultivated under tank irrigation under tanks which do not receive supplies of water until very late in the North-East monsoon; the ragi is raised with the help of such rainfall as may be received supplemented by the tank water if available. Under these tanks ragi is the crop grown in the monsoon season, and the rice crop follows in the hot weather.

Special Dry Farming Practices.—The methods of cultivation of ragi adopted in different parts of the Mysore State illustrate the principles of "dry-farming", and are all well designed to conserve rainfall and soil moisture so as to reduce, as far as possible, the risks of crop failure. For example, the practice of ploughing the dry fields immediately after harvest is universal in tracts where crops are harvested early and further rains permit of such ploughing. By this method not only is the soil moisture conserved against the drying action of the following hot weather but the soil is left in such a condition as to soak up, without loss by surface drainage, the very first rains of the succeeding season. Wherever the nature of the soil will allow of such ploughing after harvest in the hot weather it is adopted, in the belief that such ploughing almost amounts to the application of manure. Where the soil is too hard to take the plough, the heavy bladed harrow is used so that the surface is left with a loose soil mulch on it. Ploughing and cultivating are many times repeated to obtain a very good tilth before sowing, to prevent weed growth and to conserve moisture after every rainfall. The seed is invariably sown in rows for facility of thorough interculture by means of bullock implements; considerable thinning of the crop and thorough weed removal are secured so as to reduce the drain on the soil moisture and to husband it for the use of the crop. Seed is often sown mixed with manure so that the seedlings obtain a good start. If the soil is loose and blowing, then it is firmed up or

slightly compacted after sowing so as to bring up the moisture to the germinating seeds, by the curious expedient of driving a herd of sheep round and round over the field. Crust formation on the sprouting seed is broken up and loss of moisture prevented. There is furthermore the system of mixed cropping which is very general and in which a pulse crop like 'togari' or 'avare' is sown along with the 'ragi'; by this practice the best use is made of the rainfall. If the rains are unfavourable for ragi, they often benefit the 'avare' or the 'togari' and *vice versa*, so that some one crop is obtained even with a poor or untimely rainfall and a total crop failure is guarded against.

Rotations.—1. For Dryland Ragi.—A good proportion of the ragi grown in the main season, *i.e.*, 'hain' ragi, is grown without any definite rotation. The practice of growing mixed crops of ragi and avare, *i.e.*, a cereal and a legume which is very general probably avoids the need for a definite rotation which may otherwise be necessary. In recent years however owing to the popularity of the groundnut crop, it has become the custom to rotate ragi with groundnuts. It is also usual to sow an early crop of 'gingelli', fodder jola, or green gram, and follow it with horse-gram in the first two cases and with fodder jola in the third case and then sow ragi in the following year. In this way two minor crops are grown in one year and the major crop *viz.*, ragi is grown in the following year. Very often owing to the great delay in the rains, the sowing season for 'hain' ragi is missed or if 'hain' ragi was sown and becomes dried up for want of rains, then a crop of horse gram or a minor grain crop like 'baragu' is raised in the late rains, and is followed in the next year by ragi. In the 'kar' ragi tracts where it is generally possible to raise two crops in the year on the same field, several rotations can be made out. In the jola growing tracts, ragi is rotated with jola. Jola is grown together with a mixed crop of 'togari' and in the next year is followed by ragi. A favourite rotation is to follow jola or 'kar' ragi in the same year with a second crop of horse-gram and 'Hutchyellu' (niger) and then with either jola or ragi in the following year. Similarly 'gingelli' followed by horse-gram and 'hutchyellu' in the first year is succeeded by ragi either pure or with a mixed crop of 'togari' in the second year. A ploughing of the field after the harvest of the main crop is an invariable practice, where a second crop is not sown. If a mixed crop is not sown along with the ragi or jola then the whole field is ploughed. If a mixed crop is sown, then the space occupied by the jola or ragi alone is ploughed carefully sparing the rows of the 'togari', which is greatly benefited by the ploughing. If a mixed crop is grown with ragi or a second crop is grown in the same year, then on account of the delay in preparing the field for the next year's ragi crop, the latter is transplanted instead of being sown, a practice which makes up for the delay. Considerable

ragi is also grown in these tracts on the black soils and in this case the second crop in the same year is Bengal-gram. Other grain crops like 'navane' (Setaria Italica) and 'save' (Panicum miliare) are grown at intervals of two or more years, and among economic crops tobacco is grown as the single crop of the year, also once in three or four years. On rough land castor is grown for two or three years and is then followed by ragi. In some districts like Hassan, the practice of growing ragi by transplanting is very common and in these tracts chillies, American cotton, and tobacco enter into the rotation, generally not oftener than once in three years.

2. *For Irrigated Ragi.*—Irrigated ragi is grown either completely under irrigation like a garden crop or with irrigation only as supplementary, as in the cases where the ragi crop is grown on wet land under tank irrigation. In the latter case the rotation crop is only rice, or on a small scale sugarcane also, either of which follows in the hot weather following. In the former case, *i.e.*, where the ragi is grown as a garden crop, a variety of crops enter into the rotation, out of which one or other is grown according to the individual farmer's choice. It is generally a money crop which may happen to be the most paying at the time. These crops comprise tobacco, sugarcane, sweet potatoes, maize, chillies, brinjals, turmeric, groundnuts, chrysanthemums, potatoes, onions, etc. There is however a certain amount of specialisation in the different tracts, and one or other of these constitutes the chief rotation crop or the one special to that area. For example, in the Mysore State, potatoes and onions are special to the taluks of the Bangalore and Kolar Districts, turmeric is special to Goribidnur, chrysanthemums to Malur, and tobacco to Sira, Madhugiri, Goribidnur and so on.

Preparation of the Field.—The soil for ragi is prepared as thoroughly as possible. The first ploughing takes place as already referred to, immediately after the harvest of the previous crop. Where the soil becomes too hard to take the plough, a shallow stirring up at least should be given by means of the heavy 'kunte' (bladed harrow) or a disc harrow. In view of the decided advantage which the ploughing or stirring of the soil at this season affords to the succeeding crop of ragi, it is a practice which is strongly to be recommended. If the land is thus ploughed or stirred, the ploughing proper can begin with the very first shower of rain. Otherwise a good soaking rain will have to be awaited and the ploughing commenced only thereafter. With every succeeding rain the ploughing is repeated, or in the alternative the 'kunte' is worked. The improved mould-board ploughs are a great advantage and effect considerable saving in the number of ploughings required. A like saving can also be effected by using an iron six-shovel cultivator for the subsequent working of the ploughed ground. By these means

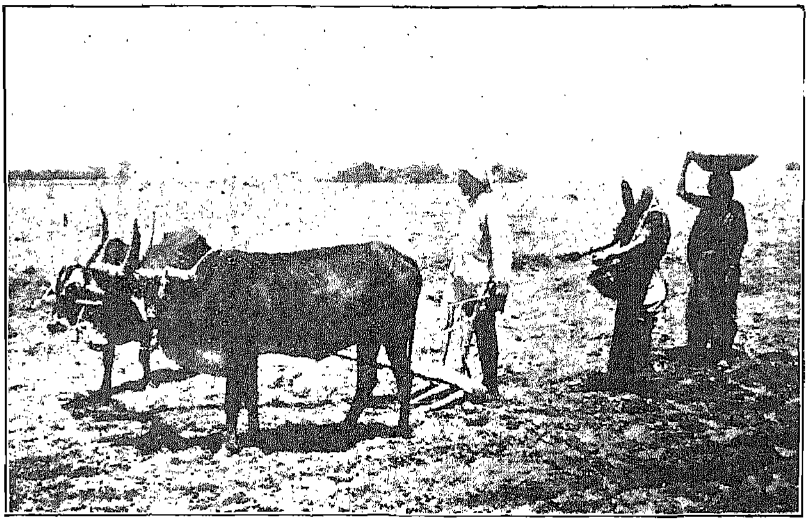
the field is stirred completely to the depth required and in case the improved ploughs are used, the soil is also inverted and the roots of weeds cut and exposed to the sun. The clods are also broken and the weeds freed from them and brought to the surface. The further working with the cultivator or a toothed harrow gathers the weeds which now should be burnt. Manure is now spread and mixed either by ploughing again or by working the cultivator. Where these improved implements are not in use, it is usual to apply the manure after the land has been ploughed twice or thrice and then to give one or two additional ploughings to work the manure well into the soil. The seed bed is usually very thoroughly prepared and looks exceedingly clean and in very good tilth. Immediately prior to the sowing, the field is worked with a light wooden-toothed harrow and the surface made quite fine and level.

Manuring.—As ragi is the main food crop of the farmer, ragi fields are manured to the fullest capacity of the stock on the farm and is further supplemented in various ways such as by the carting of silt from tanks, of fresh red soil from spots considered fertile and of earth from old village sites and mounds which have considerable manurial value and lastly by the penning of sheep. During the rainy months when the crop is on the land, a good deal of red earth is carted on to the manure heaps or pits and the dry leaves of the autumn are gathered and added and the whole turned over several times and kept covered up with more earth. In this way the manure is increased in quantity and improved in quality. During the hot weather, tank silt from dry tank beds is largely carted on to the fields and the soils thereby improved both in physical condition and in fertility, the village tank too benefiting incidentally in the process. The penning of sheep which is a common practice in the tracts where sheep are largely kept such as in parts of Tumkur, Hassan, Mysore and Chitaldrug, is a favourite form of manuring both for dry land crops as well as for valuable irrigated crops like sugarcane, tobacco and so on. The amount of cattle manure applied may vary from fifteen to twenty cart-loads per acre which may be supplemented by another ten to fifteen cart-loads of silt or red earth. Cattle manure is applied not only when the soil is being prepared as described above, but in certain tracts it is used mixed with the seed and applied in furrows at sowing time. Artificial manure and oil-cake are also applied and the latter is usual in several villages. It is applied at a later stage when the inter-cultivation is coming to an end. The use of artificial manure is hindered by the consideration that in the case of dry land ragi, the rainfall may turn out to be poor and thus render the costly manuring infructuous. This does not apply of course to irrigated ragi. With a basal dose of four cart-loads of cattle manure per acre, a mixture consisting of 50 lbs. of sulphate of ammonia and 40 lbs. of

superphosphate of lime is recommended per acre, to be applied at the time of the first weeding.

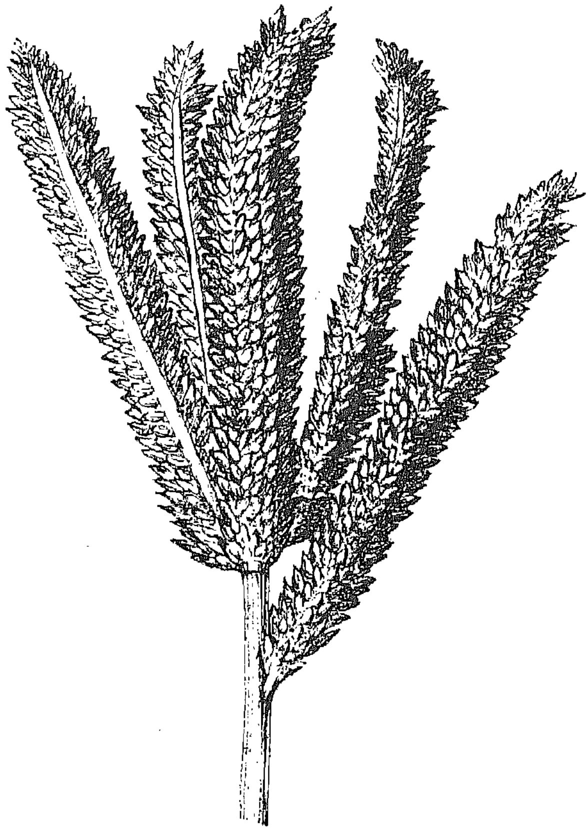
In view of the very low organic matter in the ragi soils and the great need for enhancing it so as to make the soils more receptive and retentive of moisture, the question of growing a green manure crop and ploughing it in has been studied. It will be possible to grow a sufficient quantity of some green manure crop like sunnhemp or one of the pulse crops, if these can be sown early enough. This can be done only if the soils had been ploughed after the harvest of the preceding crop. In that case a green manure crop can be sown in April or early in May, which may make a moderately sufficient growth to be ploughed in in the month of July. It has been found that an interval of about two weeks is required before the green material disintegrates in the soil. As ragi can be sown almost up to the end of July or even the first week of August, it will often be possible to adopt this practice of growing a green manure and ploughing it in for dryland ragi.

Sowing Methods.—1. *Drilling and types of seed-drills.*—Ragi is sown broadcast or in rows through seed-drills or in shallow furrows, or may be transplanted. By far the commonest method in Mysore is to sow it in rows through drills or in shallow furrows. Seed-drills are made of more than one size, some sow twelve rows and have twelve seed tubes and tynes. Others sow six rows and others again only three rows. The two latter types sow rows much wider apart than the former, *viz.*, at about 10″ apart as against 5″ or 6″ of the twelve tyne types. These seed-drills are all construtced on one common pattern but differ slightly in detail. They consist of a piece of timber roughly rectangular in section and about 4″x6″, and in length varying from 3′ to 6′ according to the type. Holes are bored through this timber at equal distances according to the width of the rows it is intended to sow, that is, either 5″ or 10″. Into these holes are fitted the tynes which are about 6″ to 9″ in length and are made of bamboo hollows about one inch in diameter. The lower or free ends of these tynes are cut slopingly. These tynes make the furrows and also pass the seeds into the soil in the furrows, and the sloping cut at the end prevents the earth from clogging the end and stopping the flow of the seed. This arrangement is for the lower portion of the drill. At the upper end of the holes in the timber are connected the seed tubes which communicate with a seed bowl mounted at the top of these seed tubes. These are generally hollow bamboo with the inner partitions at the nodes knocked through; occasionally metal tubes can be seen substituted for the bamboo. These seed tubes, twelve or six or three in number according to the type of the seed-drill, converge at the top and communicate with the seed bowl, each tube with one hole in the bowl. The seed bowl is a piece of hard wood shaped like a pair of stemless



Sowing ragi mixed with cattle manure, in furrows made by using the tynes only of a three-tyned drill. [Mys. Agri. Dept.

Sowing ragi with a twelve-tyned seed-drill, and the mixed crop with a single tube drill called 'Sadde' at the same time. [Mys. Agri. Dept.



Ragi earheads, the three main types, as regards shape :
(a) Open type,

funnels connected together hour-glass fashion. Through the constricted centre at the bottom of the top funnel are bored holes in a circle as many in number as the rows which the drill is intended to sow. It is with the lower end of these holes that the top ends of the seed tubes are connected. The bowl is placed firmly over the seed tubes and the whole arrangement is tied up by means of ropes, which pass through rings and holes on the timber and the seed bowl at appropriate places. When so tied up, it forms a rigid enough implement The timber is provided with a pair of light yoke poles for bullock draft. Variations are seen in the tynes, which are sometimes hollow and serve both for opening the furrow and passing the seeds through, and sometimes are solid and serve merely as furrow openers, the seeds in this case dropping merely through the holes in the timber into the furrows. In some an extra hole is provided in the timber which communicates slantingly with the hollow tyne and is made use of to pass a thin rod through occasionally and clean up the tyne and prevent clogging. In others there may be a 'line marker' at either end placed at half the distance between the tynes, which is merely a solid rod or peg and which marks the tracks along which the marker is to travel when the drill turns round and sows a second strip. The size of the seed bowl and of the holes therein are varied according to the kind of seed that has to be sown, being larger for jola, rice, cotton and groundnuts and small for ragi or gingelli and 'navane', etc. When rigged up complete the instrument stands about three to three and a half feet high just about high enough for feeding the seed into the bowl from the seed bag or basket tied to the waist of the person sowing the seed. Another little drill frequently employed is the 'sadde' which sows only one row and which is used as an adjunct to these drills and sometimes also independently when required. This 'sadde' consists of a seed bowl like a large crude funnel communicating with a single seed tube tied behind one of the tynes of the larger drills; it sows the mixed crop at the appropriate distances. Independently it is tied behind a plough and sows seeds in the furrow made by the plough and is made use of for sowing rice, castor, groundnuts, etc., in drill rows.

The field having been prepared thoroughly for sowing, ragi is drilled through one or other of these drills. Three persons work at the drill one to drive the bullocks, one to sow the grain and one to sow the mixed crop. With the twelve tyned drill the 'sadde' is tied to the middle of the drill and the result is that eleven rows of ragi alternate with one of 'avare'—the mixed crop usual in these tracts. With the six tyned drill the 'sadde' sows the last furrow, the appropriate hole in the six holed seed bowl being plugged for this purpose, with the result that five rows of grain alternate with one row of 'avare'; and in the three tyned drill the 'sadde' is tied to the middle tyne and is used at

every alternate journey of the drill along the field, the appropriate hole in the three holed seed bowl being plugged at the time. This also results in five rows of grain being sown alternating with one row of 'avare'. After the sowing is finished a brush harrow made by tying together a number of leafy branches in a flat layer of about six feet in length is dragged over the field to cover the seed and to smoothen the surface. Seeds are also covered by working the light bladed 'kunte'.

2. *Broadcast Sowing.*—If the soil is somewhat wet and the drill likely to be clogged, then seeds are sown broadcast even where drill sowing is the practice. Elsewhere seed is sown broadcast as the regular practice and covered by a shallow ploughing. The mixed crop is then sown by a 'sadde' tied behind a plough and drawn at regular distances of about six feet from each other. The seed thus sown is covered by ploughing another furrow adjacent to the drilled furrow, or by pushing the earth into the furrow by the feet. In these tracts the sowing of the ragi seed is followed by compacting the surface, for which purpose a herd of sheep is driven round and round all over the field.

Other Methods.—Another interesting method is to sow the ragi mixed with cattle manure. For this purpose furrows are drawn by means of the three-tyned or two-tyned drill, with the seed bowl and seed tubes removed. Seed ragi is mixed with cattle manure at the rate of about 2 lbs. of seed to a cart-load of manure which is of course in a dry and powdery form fit for such mixing and sowing. The mixture is filled into a large basket tied to the waist of the person sowing the seed, and from this it is taken out and strewn into the furrows in large handfuls. The field is then worked with a light bladed harrow and the seed covered. A variation of this practice is to put the mixture at regular intervals in the field instead of in continuous rows as above. The field is worked lengthwise and breadthwise by one of the above furrow-making drills and at the intersections of these furrows a large handful of the mixture is put in, and the field then worked with a light bladed 'kunte' for covering the seed.

The mixed crop sown with ragi is either 'avare' or 'togari', but it is also common to sow a few rows with fodder jola. This jola becomes ready about the month of September when the special feeding of the bullocks begins to bring them into condition for sale.

Selection of Seed.—The seed ragi is so liable to be mixed and poor in quality that considerable care is necessary in sowing seed of good quality. Much mixture of immature, shrunken and small seeds is general due to seeds from late formed ear-heads and seeds not fully developed for the lack of sufficient rains in the later stages. The ragi grain itself is so small that this mixture is not readily noticed. Risks due to poor seed are guarded

against by sowing an unduly large quantity of seed which is the invariable practice. At winnowing time however seed is generally taken from the best part of the heap which contains the heaviest seeds and thorough cleaning is also usual among good cultivators. Such seed is not however always available and seed grain is bought or borrowed from lots intended for food and is poor in quality as seed. It has been found that heavy grains selected by the salt-water method—described under Rice—yield a better crop than unselected seed. This procedure is therefore recommended. The same object can be achieved by separating the largest grains by putting the seed grains through a sieve of suitable mesh; the largest grains are also the heaviest.

Seed Rate.—The seed rate for ragi is usually very high; about 20 to 25 lbs., of seeds are sown per acre which is really some five or six times the quantity necessary. The large quantity is used principally to allow for the unduly large thinning which takes place during interculturing and to guard against non-germination owing to lack of moisture in the soil or the poor quality of the seed. For the same reason 'avare' and 'togari' are also sown thick, at the rate of about 10 to 15 lbs., an acre.

Interculture and After-cultivation.—Ragi seed sprouts very readily without the need for any dormant period; in fact, grains can sometimes be seen to sprout even in the ear-heads if harvest is greatly delayed and a heavy rain should fall at the time. Germination becomes poor as the grain becomes old and especially in the peculiar methods of storage adopted. The grain should therefore be tested for germination. A common way is to judge from the appearance of the grain and its smell, and further to soak a little of the grain tied up in a small piece of cloth in water overnight and then keep it moist until the grains sprout. A fairly good idea of the germination capacity is thereby obtained but it will be advisable to make a regular germination test with a proper representative sample of the grain. Considerable benefit accrues from a selection of ear-heads for seed in the field itself.

The ragi grain has to be sown very shallow, in depths not exceeding an inch or an inch and a half, and this is well accomplished by the light bamboo drills used for the purpose. Efforts have been made to improve these local drills so as to dispense with the feeding of the grain into the bowl by hand which is uneven or sometimes even patchy and replace it by the regularity of some mechanical means such as by mounting the drill on wheels and gearing the feed to the axle. The construction necessary for this purpose makes the machine heavy. The seeds are sown deeper and the grain is fed too thick. After many trials, a small drill for mechanical sowing has been constructed in Hebbal, Mysore, which successfully overcomes these difficulties and may, if made in large numbers, be cheapened in cost considerably.

In five days the mixed crop is well above-ground and in a week the braids of both ragi and mixed crop are well up and visible and interculturing begins very soon after, about the fifteenth day after the sowing. Even before this period, in case rain has fallen in the interval and a soil crust has formed, a light harrow is worked on the field and the crust broken up. In the drill-sown ragi field the interculturing is by a light bladed harrow whose blades just straddle the rows of ragi and work close on either side; where the six or three tyned drills have been used and the rows are wider the interculturing tool works between the rows. In the case of broadcasted fields the interculturing tool has two teeth like large chisel points; these tools are worked first along the length and later across the width of the field. A good proportion of the ragi and 'avare' seedlings are uprooted in the process and removed along with the weeds. In fact in every one of the first two or three of the intercultures a good amount of thinning of the fields takes place. Altogether interculturing with these bullock hoes is carried out at least three times, at intervals of about a week; after this and about a month and a half from sowing a thorough weeding by hand tools is given and this completes the work on the field till practically harvest time. Occasionally if the crop is growing over-luxuriantly, bullocks are let into the field for a light grazing in which the tops are eaten off by the animals and the excessive growth is kept down.

Transplanting Dryland Ragi.—Ragi under dry cultivation is also transplanted. Much of the 'kar ragi' and considerable 'hain' ragi are both raised by this method. Seedlings are raised in special nurseries and thinnings from broadcast or drill-sown fields are also made use of for being transplanted. Fields for transplanting continue to be prepared for a longer time than when seeds are sown and the transplanting is done after the rains have well set in and the soils moistened to a good depth. After the field is well prepared, furrows are drawn lengthwise and breadthwise, chessboard fashion, by working a cultivator with two tynes or the furrow openers only of a three-tyned seed-drill lengthwise and across the field. At the intersections of the furrows one or two seedlings are planted and some cattle manure is also applied. At the same time all blanks in the sown fields are filled with transplanted seedlings. Later operations comprise interculturing at frequent intervals as for sown ragi. With transplanted ragi mixed crops of 'avare' or togari' are seldom sown.

Harvesting and Threshing.—The 'kar' ragi becomes ready for harvest about the end of August, that is, four months from sowing. The ragi is harvested with ordinary sickles and the loose sheaves are allowed to lie on the field for several days as there are rains at the time and the sheaves could not be put up in stacks. After the stalks are somewhat dry they are put up in small field stacks and allowed to remain there till the rains have completely ceased and are then removed and put up in large

stacks near the threshing floor only about the month of November.

The main season ragi heads out from the beginning of October and is fully in earheads in about a fortnight thereafter. The earheads mature and become ready for harvest in about forty days and the harvest begins from the middle of November and may continue up to the middle of December depending upon the variety and month when the crop was sown. The crop usually takes about five to five and a half months to mature. Harvest is by means of ordinary sickles and the plants are cut close to the ground so as not to waste any of the straw which is considered very valuable; the sheaves are tied and put up in large field stacks temporarily or carted straight away to be stacked on the threshing floors. Ragi remains in the stack for a month or two until the dewy season is over and the weather permanently warms up about the middle of February. By this time all the mixed crops are also harvested and the threshing begins. The mixed crops, like 'avare' and 'togari' and the minor crops like horse-gram, niger, and 'gingelli' are all threshed first and the ragi itself is taken up last. The threshing of the ragi is done in one of three ways, *viz.*, by beating out the grains with sticks in the manner of threshing under flails, by treading out the grain under the feet of oxen which are driven in a team round and round over the sheaves spread on the ground, and lastly by working a stone roller over the sheaves. The first method is both slow and laborious and requires a good deal of manual labour and is unsuited for any but the very small farmer. The sheaves will have to be well dried in the sun and are put out until about 1 or 2 P.M. in the after-noon; they are then spread thin and the earheads are beaten by long bamboos, by men in a sitting posture and using both hands with a stick in each hand. In the course of three and a half hours two men usually thresh out 125 to 150 lbs., of grain. The second is the commonest, and until the introduction of the stone threshing roller, was the only method in general use. About six to eight oxen are tied abreast in a team and are made to walk round and round over a thick layer of well dried sheaves which are spread circularly on the threshing floor around a central post to which the animal in the team nearest to the central post is loosely tied. After this threshing there is always a small proportion of earheads left unthreshed which has to be beaten out. A team of ten animals with ten men (one to drive the team, one to rake the sheaves, four to beat out the grain and two to winnow the grain for two days) forms a unit, and will thresh about 1,200 to 1,500 lbs., of grain as the result of a day's work. A good day's work with well-filled earheads will amount to about 1,200 to 1,500 lbs., of grain (mixed with chaff, etc., to be removed later).

The stone roller already described under 'Rice' is simpler, and needs only one pair of bullocks and much less co-operation

from neighbours. It will also turn out in a day the same amount of work, *i.e.*, about 1,200 to 1,500 lbs., of grain mixed with chaff, bits of straw, etc. The straw from the cattle threshing is considered softer and to be better relished by stock than the straw from the roller-threshing but practical convenience has overcome this objection to the use of the latter which is now bidding fair to become the general practice. The threshing of the ragi is more difficult than that of rice or of jola, as the grains are held much more firmly in the glumes and require considerable pressure; some varieties are however easier and are indeed subject to a certain amount of loss by shedding.

A small American threshing machine called the "Little Giant" and driven by a 6·5 H. P. oil engine was introduced in Mysore and was worked on the whole with much success. It is even now in use in at least one large private farm. A certain amount of breakage of grain, and a small percentage of unthreshed earheads were the defects in the beginning, but were largely overcome later on by suitable alterations. The cost of the outfit however puts it beyond the means of individual cultivators.

Yields.—The yield of dryland ragi in good seasons is about 1,500 lbs. of grain per acre but on the average will seldom amount to more than about 900 lbs. The straw of the ragi is regarded as highly nutritious fodder and is all carefully conserved by putting up in large well built stacks. About a ton of straw is expected generally per acre.

Cultivation of Irrigated Ragi.—Ragi grown under irrigation is usually a short season variety called 'gidda ragi' — as distinguished from 'dodda ragi', the main season dryland ragi — and this is about a month earlier like the 'kar' ragi. Irrigated ragi is sown and raised as already stated, just like dryland ragi, an irrigation or two being given when necessary or as a fully irrigated garden crop depending entirely on irrigation. In the former case it is usually a rainy season crop and both 'dodda ragi' and 'gidda ragi' can be sown, and in the latter case it is a hot weather crop and only 'gidda ragi' is sown. The cultivation in the first case is more or less as for dryland ragi, with the exception of the occasional irrigation.

The irrigated crop proper is cultivated by transplantation. The field is prepared and manured well and then is laid out for irrigation into small beds about 8′ × 4′. Seedlings are raised in a separate nursery and a pound of seed ragi will give all the seedlings necessary to transplant an acre; seedlings are left from three weeks to a month in the nursery before transplanting. At transplanting time the nursery is heavily watered and the seedlings are pulled out and topped and are then transplanted at distances of four inches from each other in the beds which are also heavily watered. Unlike rice, the seedlings are transplanted almost invariably in singles. The beds are irrigated on the third

day after transplantation and then once a week regularly; in the case of good retentive soils like the black clayey loams, the irrigations are less frequent and are given once a fortnight, taking care only that the soil does not crack. At least one hoeing with hand hoes is given a month after transplanting and then a hand weeding with a weeding hook. The crop comes to maturity in four months and is harvested by cutting off only the earheads. The straw is grazed down as much as cattle may eat and the stubble is cut and stacked to be used for thatch, bedding for cattle, fuel or manure. The earheads are put out to dry and the grains are beaten out with sticks. Irrigated ragi on well manured lands yields as much as 3,000 lbs., of grain and on the average 2,000 to 2,500 lbs.

Methods of Storage.—Ragi grain in Mysore is preserved in ordinary earthenware receptacles like other grains and to a much larger extent underground in large pits excavated in suitable places inside village limits, within the street itself or in selected fields. The chief requirement for such pits is that they should be on dry and high ground with no chance for any water to percolate inside. They are dug in the shape of a huge pot with a narrow neck and may be seven to eight feet deep, sufficient to hold 2,000 to 3,000 seers, or 2 to 2½ tons of grain. Both larger and smaller sizes are also common. The neck is narrow, about 18 to 24 inches in diameter just enough to allow a thin person to climb down. Before filling the pit with the grain, the walls and floor of the pit are smoothened and plastered with cowdung paste and are lined with loose straw or with long straw twist. The pit is then filled, the neck well plugged with straw and then covered over with a heavy stone slab and then with earth in the shape of a small but inconspicuous mound. If water does not enter, and the pit remains quite dry, the ragi in these grain stores lasts indefinitely. Stories are told of ragi having been kept even for fifty years without damage. But if moisture should get in, then the ragi undergoes fermentative changes which result in the formation of ptomaine poisons. The stench which emanates when such a pit is opened is foul in the extreme and will pollute the air over a wide area. Even ordinarily the air inside the pit is tested by letting down a fowl before a person ventures to get in for taking out the grain. Deaths are reported to have taken place as the result of having eaten grain from some pits, which are considered to be due to ptomaine poisoning. The practice of storing ragi in such pits is however rapidly going out as the grain is no longer stored for any long periods and as the ordinary grain bag is considered serviceable enough for the present periods of storage. Bulk storage in good metallic bins, earthernware bins or in suitable rooms or wicker bins are all adopted, now that the need for storage over many years is no longer felt.

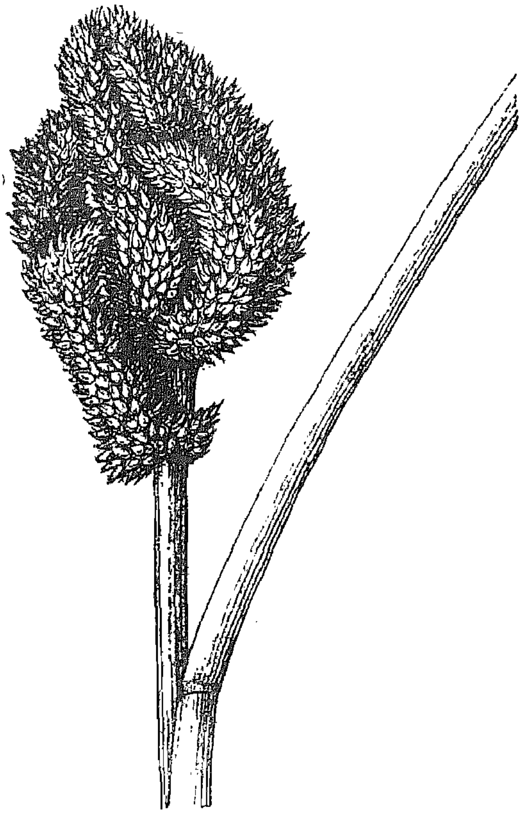
Botany and Varieties.—Ragi known botanically as Eleusine coracana belongs to the natural order Gramineae, and is a member of a group of grasses which have flattened stems and round nodes. They are dwarfish in habit, tiller profusely and bear at the end of the culms earheads which consist of a whorl of fingerlike spikes two or more (up to six or eight) in number in which the spikelets are arranged closely on both sides of a slender rachis, two to four inches in length. The spikelets contain from three to eight seeds which are very small, often minute in size. The seeds show prominently from between the glumes in the cultivated varieties, whereas in the wild species E. indica and E. ægyptiaca the grains are smaller still and are well enclosed in the glumes and pales. The ragi flower is invariably self-fertilised.

The root system of the ragi plant consists of a remarkably large number of strong slender fibrous roots, which radiate from the base of the plant all round it. The roots are not much branched but make up by the number of primary roots themselves. They permeate and hold the soil so firmly that it needs a very strong man to pull out a fully grown ragi plant by its roots. The roots are apparently able to absorb moisture very thoroughly and efficiently from the soil, as the plants are able to live through very severe drought when the soil moisture is very low and revive surprisingly after a shower of rain. The roots cannot be called deep or wide spreading and are generally not more than a foot in depth or 18″ in spread.

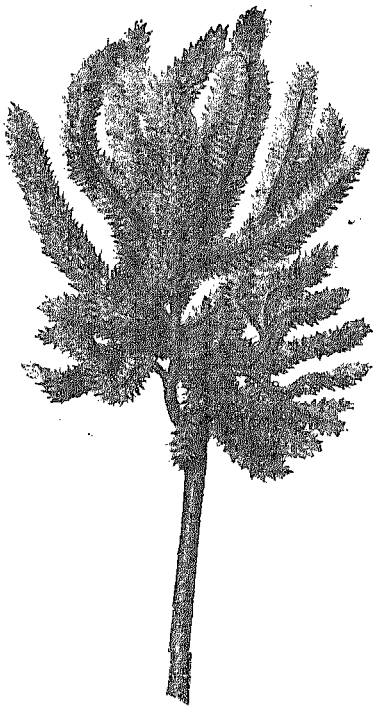
The plants tiller profusely and have further the peculiarity of sending out branches at each node, one after the other, especially if it happens to grow somewhat prostrate and with wide spacing ; a trampling down of the plant will have this effect and a very large number of bearing stems with earheads formed successively and therefore in all stages of development can be seen on such plants. This tendency sometimes leads to the presence of a number of immature earheads even at the time of the harvest.

The varieties of ragi under cultivation differ in the season or condition for which they are suitable, in their period of maturity, in the habit of growth, in the size, shape and colour of the earheads, in the size and colour of the grain, in their yielding capacity and the quality of the grain. As regards seasons and conditions, two types are sharply distinguished—those belonging to the 'kar' ragi and those belonging to the 'hain' ragi tracts, and those suited for irrigated cultivation and those for dry cultivation.

In regard to maturity, the varieties may be distinguished as early, medium and late maturing, the period ranging from four to five and a half months. In habit of growth some have a dwarfish habit while others grow tall and up to about four feet in height. In respect of earheads, they are broadly of two types, those in which the spikes are curved inwards and have a compact



(*b*) Closed type, and



(e) Coxcomb type. [Mys. Agri. Dept.

appearance and those in which the spikes are straight and the earheads have an open appearance. There is also a special type in which the spikes are branched, short and thick somewhat like a coxcomb. In both these types there are those which are green in colour and those which are deep violet almost dark in colour. In these latter, the purple or violet colour is seen in the nodes and to some extent in the leaf margins. Varieties may therefore be classified as those with violet open, violet closed, green open, green closed, violet coxcomb or green coxcomb earheads and again according as they are early or late or suited to 'kar' and 'hain' and so on. Among the open earheads more conspicuously, and in the closed earheads less conspicuously, varieties differ in the length of the spikes, some being as short as two inches, and others quite four inches in length. The spikes are well filled or portions of the rachis are blank.

As regards yield, the open types are as a rule higher yielding than the corresponding compact types, and the long duration varieties are better than the short duration varieties. The open types with the long spikes are however liable to shed and to be brittle, the spikes breaking during the harvesting, carting and stacking. In spite of their smaller yield, therefore, in some localities the compact types are preferred on account of their freedom from these defects. As distinct from the varieties grown in Mysore, North Indian varieties are very poor, both in growth and in yield, but have the merit of being very early.

The varieties grown in Mysore are known by a number of local names which are either descriptive of the earhead or bear the name of the village from which the cultivation spread. Pure strains have been isolated from the best varieties, compared for their yield and are now being popularised under different numbers. Some of the main varieties possess the following characteristics :—

Hullubili	... Green open type	... Medium.
Gudabili	... Green compact	... Late.
Karigidda	... Violet compact	... Do
Jenumudde	... Green open	... Do
Madayangiri	... Violet open	... Do
Hasarukambi	... Green open	... Do
Doddaragi	... do	... Do
Biliragi	... do	... Do
Balepatte	... do	... Medium.
Karimarakalu	... do	... Late.
Majjige ragi	... do	... Early (white grain)
Do (another type)	... Green compact	... Do
Rudrajade	... Violet compact	... Coxcomb, irrigated.
Jade Shankara	... Green compact	... Do

A selection which is now generally grown is H_{22}, a selection from Madayangiri ragi. H_{40} a selection from Hullubili is also a

popular type. Many other types are being put out as the result of the work of plant selection which is continuously in progress.

Varieties differ in the colour of the grains and in their sizes. A deep brown colour is the predominant colour of most varieties, but shades of this colour ranging from orange red at one end and very deep brown almost black at the other are met with, which are varietal characteristics, even making allowance for the fact that on storage and on account of rain in the stack the colour tends to deepen and change. A distinct type is a white ragi in which the husk is also white. There are like variations in the size of the grain although this is so only within very narrow limits. Differences in quality of the grain are also recognised, though to some extent opinions differ in respect of them. Some are considered better in taste, others are said to give more or less pudding from the same weight of flour, and still others are said to yield a pudding of poor consistency pudding which cannot be kept overnight and used and so on. These are all probably correct and due to variations in the composition of the grain, though few investigations have been made to test their correctness and to find out the reason. Reference may be made however to some work on the comparative values of the proteins in brown ragi and in white ragi, in which it was found that the growth promoting value of the proteins of white ragi is much higher than that of the proteins of brown ragi and the digestability co-efficient of the former also likewise much higher than that of the latter.

Pests and Diseases, 1. *Insect Pests.*—Ragi is a crop which is singularly free from pests and diseases. The only insect pest of any importance is the hairy caterpillar *Amsacta albistriga, W.* which does considerable damage in the eastern parts of the Mysore State. The moths of the caterpillar emerge with the advent of rains in May and June and the caterpillars hatch out about the time the young ragi comes up on which they prey, as they do on other vegetation as well at the time. The remedy that has been recommended is the catching of the moths and destroying them. The moths are rather sluggish and can be easily caught. Little boys and girls can do the work quite effectively and in many villages the pest has been kept under control in this manner by arranging for excursions by groups of school children for the purpose.

Another pest which like the caterpillar pest attacks ragi along with many other crops and vegetation is the jola grasshopper—*Colemania sphenareoides*—which has the characteristic that even in the adult stage it is wingless. The pest has the peculiarity that it appears at intervals of a certain number of years, which are so regular that an outbreak can be roughly forecasted. It is also confined to particular tracts where alone it appears every time that there is an outbreak. This is principally a pest of jola, but as considerable ragi is also grown in such

tracts, ragi is also attacked and serious damage caused. The pest appears about the months of May, June and July just when the crops are sown and are in a young stage. The young crop is defoliated sometimes so badly that a resowing of the same crop or a change over to some other one is necessitated. There is so far only one remedy known, *viz.*, the catching of the hoppers in specially constructed grass-hopper bags already described under rice, and then destroying the catch. As the pest comes on in successive broods over a period of two months, the bag will have to be dragged over the crop three or four times at intervals. The pest subsides very much by this time, and all late sown crops and what survives of the early sowings escape damage.

2. *Fungus and other diseases.*—In some tracts ragi earheads are attacked by a kind of smut and the grains are filled with characteristic black powder. The exact manner in which the disease is propagated is not known and the treatment of seed as in the case of the smut in jola or wheat has not been found to be of any use. The disease is however of very little importance from the point of view of the loss caused or the extent of the country affected.

Another obscure disease also of very minor importance is the slow drying up of the plants, the leaves and stems developing at the same time a red colour. It has been found to occur in varieties which have purple or violet earheads and in the nodes and leaves of which normally a purple or reddish pigment is seen. It has been noticed on soils markedly calcareous which perhaps has something to do with the malady. Arrested growth accompanied by the appearance of aerial roots from the nodes has also been reported. Phloem vessels are choked with bacteria in affected plants and this is surmised as a possible cause.

A disease which causes some damage especially in years of heavy rainfall is the fungus disease "*Helminthosporium nodulosum*" which attacks many other cereal grains in various parts of the world. The disease appears in patches in the fields and is outwardly characterised by brown rusty spots on the leaves, and similar blotches on the nodes, leaf-sheath, rachis and spikelets. Plants in all stages are liable to be attacked and in the earheads of attacked plants the grains are poorly developed. The disease is carried from year to year through infected seeds, stubble, soil and from plant to plant through spores carried by the wind. As far as infection by seed is concerned, this can be controlled largely by treating the seed with copper sulphate solution and with the proprietory fungicide called Cerasan, but the large infection from other sources generally masks such protective effect as the seed treatment produces.

Ragi is occasionally subject to the attacks of another fungus disease—*Piricularia sp*—as the result of which in serious attacks the grains are not properly filled.

Chemical Composition.—Ragi as a food grain is ground into flour and then used cooked either as a pudding or as a porridge. For making into flour the whole grain is used husk and all; the inclusion of the husks accounts for the greater food value of the ragi grain and for its coarseness as compared with rice. The chemical composition of ragi grain and straw is as below:—

	Water	Albuminoids	Fats	Carbohydrates	Fibre	Ash	
Ragi grain ...	13·1	7·1	1·3	76·3	...	2·2	(Aykroyd)
Do ...	13·2	7·3	1·5	73·2	2·5	2·3	(Church)
Do ...	9·4	5·4	1·4	78·5	2·5	2·9	(Leather)
Ragi straw ...	14·6	1·94	0·48	49·1	28·9	5·24	(Wood)

It has been found that the protein of ragi is of the type known as biologically complete as in the case of milk. The ragi grain can be malted and used as a nourishing form of food. For this purpose the grain is first soaked in water from 36 to 48 hours and removed and spread out on the floor and allowed to germinate over a period of seven days. After germination the grain is dried in the sun and then roasted over a low fire and ground into flour.

In trials on the use of various grains used by themselves for comparing their growth-promoting properties it has been found that the grains ranked in the following descending order, *viz.*, sajje (Pennisetum typhoidium), jola, ragi and polished rice. Not only is ragi considered as a very nourishing and sustaining food but it is also recommended as a specially suitable food for diabetic patients who are advised to exclude rice and eat ragi in preference.

Acreage and trade in Mysore.—The acreage of ragi in Mysore has remained very steady for many years, being approximately about two and a quarter million acres. The production was large enough not only to meet the local consumption but to leave a large surplus for export. Mysore was exporting large quantities regularly every year until 1927-28, from which year a rapid and continuous reduction in the exports has been going on. The exports during the year 1936-37, *viz.*, about 625 tons was only 3 per cent of the exports of the year 1927-28, *viz.*, about 21,140 tons when the reduction began.

III. JOLA (*Andropogon sorghum*).

VERNACULAR NAMES FOR JOLA *Kannada*-JOLA, *Tamil*-CHOLUM, *Telugu*-JONNALU, *Malayalam*-CHOLUM, *Hindustani*-JAWAR.

Jola is one of the most widely grown dryland food grains in India. Its suitability to tracts of even low rainfall and its ability to withstand considerable drought make it an ideal crop for cultivation over vast tracts which depend entirely upon rainfall. It makes comparatively quick growth and gives not only good yields of grain but also very large quantities of fodder. The existence of many varieties suited to different seasons, for growing both as a dry crop and under irrigation, for purposes solely of fodder and of both fodder and grain greatly widens the scope for its cultivation. The cultivated sorghums have a wide range of distribution stretching from North China and Japan to Southern Australia. Over vast stretches of China and Africa it forms one of the main food crops of the local inhabitants while elsewhere as in America and Australia its use is largely as a cattle feed. Varieties exist which have a sweet stem like the sugarcane and which are grown largely in the southern parts of the U.S.A. and are milled for the sake of the sugar in them, though this is mainly in the form of syrup. The sorghum is a crop *par excellence* of the plains though on the Mysore plateau it grows at an elevation of about 3,000 feet. The average temperature during the growing season ranges from 80 to 90 degrees F. but many varieties can stand a temperature of 60 degrees F. as a lower limit and about 105 degrees F. as a maximum. Sorghums are crops suited only to regions of low or moderate rainfall and are limited to tracts with about 40 inches as a maximum. They mature however with a much smaller quantity of rainfall in the growing season than ragi, about 10 to 12 inches from sowing to harvest being sufficient. Below an annual rainfall of 17 or 18 inches it cannot be grown as a dry crop and will have to be raised under irrigation.

Soils.—The cultivation of jola is largely associated with the black cotton soil, it is indeed the main food crop on these soils. Under proper conditions of moisture in the soil in a normal season with no pests or diseases to keep it down the crop attains remarkable growth on these soils, reaching a height of over ten feet and giving very large yields of both grain and fodder. The crop is by no means confined to the black cotton soil but is grown even to a larger extent on other types of soils also, the red, ashy grey, light red and so on. Except on stony, gravelly or such rough soils jola is grown on a wide variety of soils, both heavy and light loams and even

sandy soils. The best crops are grown however on the clay loams whether red or black in colour and, if under irrigation, with adequate drainage. On low lying fields and on dry tank beds the crop makes very luxuriant growth but if water stands for any length of time or the moisture does not drain off soon the crop becomes sickly and yields only a poor crop.

Rotations.—There are three seasons for the cultivation of jola in Mysore as a dry crop. The earliest season begins in the first week of April when the early jola is sown and this ends about the middle of August. The second or main season begins about June and ends about the month of October. The third season begins about October and ends in the month of February. In addition to these is the hot weather jola crop which is grown under irrigation; the season for this crop extends from February to May. In the case of the early jola sowings, there is usually a second crop grown in the same year which consists of horsegram and niger on red soils and one or other of Bengal-gram or coriander in the case of the black cotton soils. The jola may moreover be grown with a subordinate or mixed crop, usually 'togari' which occupies the ground for the rest of the year after the jola is harvested. Alternatively, the jola crop may be followed by a ploughed-up fallow in the second half of the year. In the following year, ragi is sown as 'kar' (or early ragi) if after fallow or as main season ragi in other cases. In recent years groundnuts are being grown in this rotation and a jola-ragi-groundnut rotation is being adopted. In the case of the second season, *viz.*, the main season, the jola is raised as the sole crop of the year, and is then rotated with 'sajje' (Pennisetum typhoidium) in the following year in all but the black cotton soils; on these latter the rotation crop is cotton either pure or mixed with a grain crop, like 'navane' (Setaria italica). In this case in recent years groundnuts have been introduced in the rotation, so largely in certain tracts as to take the place of cotton, but ordinarily in a three year rotation of jola-cotton-groundnuts. The variety of groundnuts chosen for this purpose belongs to the short season erect type—either the small Japan or the Spanish—which matures in three or three and a half months and therefore permits of an additional crop being grown in the same year which is sown either after the removal of the groundnut crop or in between the rows of the groundnuts about a month previous to the harvest of the latter. These mixed crops may include cotton, 'togare', or horsegram. This is really an intensive rotation in which two or three important crops are crowded together; but the practice of liberal manuring with artificial manures has come into vogue in these tracts, even though the cultivation is only rainfed and not irrigated. The jola cultivated in this main season, is grown with a variety of mixed crops for each of which a few rows are set apart even in one and the same field. For example, in addition to 'togare' and 'avare' which are

the principal mixed crops, cowpea, 'pundi' (*Hibiscus cannabinus*), blackgram, fodder jola, 'sajje' and even vegetable crops like brinjals, cucumber, chillies, etc., are all included in this large variety of mixed crops.

In the third season for dryland jola which is the late or north-east monsoon the jola is sown in the month of October and the rotation crop is cotton, of the indigenous or 'sannahatti' variety. In many years the rains set in too late for sowing cotton and then jola is sown instead although the previous year's crop was also jola, so that it is either a jola-cotton or a jola-jola rotation. To a small extent bengal-gram is grown as part of this rotation especially when the rains are not timely for cotton. The October rains are really the last chance for sowing a crop in these tracts and a grain crop like jola is sown, wherever possible, so as to provide both food and fodder for the following year. In addition to the ordinary arable land, many tank-beds which for want of heavy rains are dry either wholly or over the greater portion of the normal waterspread, are sown with jola in this season. This tank-bed cultivation is on a kind of co-operative basis for the whole village and the work of cultivation and later on the produce itself are suitably apportioned among the villagers. In the fertile tank-bed soils extraordinarily heavy crops are obtained of both grain and fodder. The crop attains often a height of 15 to 18 feet. It is, however subject to considerable risk as heavy downpours of rain may be received before the crop comes to harvest and a good portion of the tank fills; the crop is then completely lost or greatly damaged.

Lastly comes irrigated jola which is sown generally in February or late in January. This is more or less garden cultivation and many crops enter into the rotation, such as groundnuts, chillies, sugarcane, rice, tobacco, etc. As a variation of this method, *viz.*, as a semi-irrigated crop, jola is grown in the main season itself under many tanks where normally rice is grown but in which the supply of water is insufficient or uncertain. Jola is sown therefore as a surer crop, especially if the soils are of the heavy clayey types to which ragi is not suited. With the help of such rains as may fall, supplemented with an occasional irrigation, if possible, moderately good crops generally and very good crops sometimes are raised. In these situations jola and ragi are really the more dependable grain crops and are therefore preferred to rice.

Cultivation—Preparation of the field.—The preparation of the field for jola begins in the case of the earliest sown crops with the ploughing of the field immediately after the harvest of the previous year's crop, as a fall or autumn ploughing. The land is ploughed several times and is left in a condition almost fit for sowing. Where such ploughing is not possible then ploughing begins early in April itself. In this case the preparation

is not very thorough and in this respect jola is a notable contrast to ragi which requires very thorough preparation. In order not to miss an early sowing rain, ploughing is even dispensed with altogether and only plough furrows are drawn at the sowing distance of a foot apart and the seeds are sown therein immediately; the interspaces are ploughed later on leisurely. In such tracts sowing takes place in the first week of April and continues up to the first week of May. Normally however the land is ploughed twice or ploughed once and then worked with the cultivator or bladed harrow, cattle manure is applied at the rate of five cart-loads an acre at least and mixed with the soil by ploughing or harrowing.

A fine tilth is not attempted as a firm and compact condition of the soil in the root range is believed to be favourable for jola. Elsewhere and especially in the black cotton soils the preparation is somewhat more thorough and is carried out over a longe period of time. In the months of February and March the field is given a shallow ploughing and this ploughing, called a 'maghi' ploughing is considered of great importance and is seldom omitted, unless more important work prevents its being carried out. Later, if possible, a heavier plough of wood or iron is worked. With the first rains the clods in this ploughed soil generally crumble and the large bladed harrow—'kunte'—is used to further break the clods. The clod breaking log—or 'koradu'—is worked thereafter, which further crushes the clods and also levels the field. All stubble and old roots which are freed from the soil and brought up are gathered and burnt. Cattle manure at the rate of about seven cart-loads an acre is now applied and spread and harrowed in. The field is now ready for sowing. In the typical extensive black cotton soils, however, where large areas have to be covered, working with the heavy bladed harrows—or 'dodda kunte'—takes the place of ploughing; with the first harrowing the old cotton plants are also pulled out and with another stirring of the soil with a lighter bladed harrow the field is ready for sowing.

Sowing methods.—Jola is sown in rows either in plough furrows or through regular seed-drills. The drills used have three tynes and sow three rows at a time; the tynes are about 13 inches apart and when sowing in plough furrows the same distance between the rows is left. Immediately before sowing, the field is worked with a levelling board and behind this and at suitable distances behind each other, work three ploughs with 'saddes' or seed tubes tied behind each, sowing three rows of jola, and each sowing unit consisting of one man for the plough and one woman for the 'sadde'. At every fifth row the mixed crop or crops already mentioned are sown instead of the jola. Where sowing is through seed-drills, the sowing unit consists of only one man for driving the team and one woman for sowing the seed. At the second round of the drill

one hole of the drill is blocked and the mixed crop is sown instead of jola, through a 'sadde' in the furrow made by the tyne of the drill. Behind the sowing teams work, firstly, a light-bladed harrow—the 'balu kunte'— to cover the seed and then a levelling board to level and compact the soil. If there should be a rain after the jola is sown then the light-bladed harrow is worked again to break the crust that may be formed. In tracts where such a variety of implements is not in use, jola is sown in plough furrows either by hand or through a 'sadde', which is followed by a plough which works somewhat deeper and ploughs a furrow between two rows of jola, thereby splitting the ridge between the rows and covering the seed. Though the common practice is to sow not more than five rows in the jola strip alternating with one row of the mixed crop, variations may be seen here and there in which eight rows of jola may alternate with one of the mixed crop. The mixed crops are sown as a general rule only in rows parallel with the rows of jola and within the field but very often the headlands or top and bottom of the field are sown with these rows and then their rows are at right angles to the jola rows. Considerable fodder jola is sown in this way. Sometimes the margins of the field on all the four sides may be sown with safflower, which on account of its being thorny, acts as a hedge and keeps stray cattle out.

Seed rate.—The seed rate for jola is about eight to ten lbs. per acre and the mixed crop also requires the same quantity so that all told about 20 lbs. of seeds are sown. The seeds are usually not of very good quality, as the jola and the pulse crops used for mixing are both badly subject to pests in storage, and except when great care has been taken to preserve the seeds they contain considerable worm-eaten seeds. If good sound seed is used then a smaller quantity will suffice; but young jola is so very much subject to the attacks of grass-hoppers and hairy caterpillars that a fairly high seed rate is necessary as a sort of protection against such risk.

Treatment of seed.—Jola is subject to a smut disease which in some tracts appears every year and sometimes in a severe form. As this particular smut can be controlled by treating the seed with sulphate of copper, all seed grains should be so treated before sowing. For this purpose copper sulphate is dissolved in water in an earthenware pot in the proportion of one part in 100 parts (both by weight) of water and the seed grain is then stirred up in the solution for ten minutes; the grains are then taken out, drained thoroughly and after a little airing to dry them so that they will not adhere to each other, are used for sowing. About four tolas (1 tola = 4 oz.) dissolved in half a gallon of water (or two Mysore seers) will be enough for the abovementioned quantity of seed required for an acre. A more convenient treatment is by means of sulphur, either flowers of sulphur or finely powdered roll or lump sulphur. This is a 'dry'

treatment and consists in mixing the seed grain thoroughly with the sulphur dust. For this purpose both seed and sulphur may be put into a metal pot, the mouth tied over with cloth and the pot then well rolled on the ground. About a tola or two of sulphur will treat enough seed for an acre.

Intercultivation and other operations.—From about the seventh day the jola seeds sprout and begin to show above ground, the mixed crops appear earlier; in another fortnight the crops are ready for interculture. For this purpose the small bladed hoes—'yede kuntes'—are used. In addition to removing weeds and stirring the soil between the rows, this has the effect of slightly earthing up the rows. In another week or ten days the interculturing is repeated, for further weeding and earthing up. Sometimes a light plough itself is used for this purpose and the interspaces are ploughed. The hœs are however the more common implements and are quick and economical. Two of them are hitched to one yoke and worked with one pair of bullocks, and the use of three and even four of them to one yoke is not uncommon. Each hoe is in charge of one man and the bullocks led by another. After every rain and before the surface dries hard, the hoes are used and are worked until the rows have closed in and hoeing becomes impossible. The jola is carefully guarded against the inroads of cattle, as the stalk and leaves of the ordinary jola are poisonous to cattle which may either die or suffer from 'bloat'. Jola has the peculiarity of sending out aerial roots from the nodes on the stem, principally from the lower ones. Every hoeing results in a light earthing up of the rows which encourages considerable rooting of this kind; this gives additional anchorage to this tall-growing crop besides increasing its capacity to absorb both moisture and plant foods from the soil. The crop begins to head out in 2½ months and from then onwards up to the harvest it has to be watched against the ravages of birds which prey upon the grain both in the milk stage and the ripe stage. Perches are erected high in the fields, standing on which boys set up a din to scare the birds away. Swarms which descend upon distant patches are shot at with stones thrown from slings. The varieties of jola in which the earheads are loose and open panicles are attacked less than those with compact earheads as the former do not afford a foothold for the birds descending on them. Varieties in which the earheads curve down goose-neck fashion also enjoy some freedom from attack. Long before the jola ripens the minor mixed crops mature and are ready for harvest; these are greengram, blackgram and cowpeas from which a good deal of green pods are frequently gathered and the bulk finally harvested by pulling out the plants. The vegetable crops too begin to yield and are gathered for use and sale as they become available.

Harvesting and threshing.—In four months to five and a half months depending upon the variety sown jola comes to harvest.

Normally only one earhead is formed in each plant and ripening is very uniform over the whole field; occasionally plants bear several heads one forming after another and therefore not maturing at the same time. Plants injured by borers or broken off in the middle also branch in this way; and under other conditions also which are not well understood, plants develop these multiple earheads, leading to some unevenness in maturity. Harvesting is by pulling out the plants, or by cutting them flush with the ground with sickles or by removing the earheads only first and cutting down the plants later on. The plants, both stalk and earheads, are piled in the fields for some considerable time before removal to the threshing yards, and during this time the ploughing of the field between the rows of the mixed crops is taken up. After this work is finished, the earheads are cut and carted to the threshing floor and later on the stalks themselves. If harvesting consisted in cutting off only the earheads, these are either stored in the field in field-bins made of the jola stalks or are carted straight away to the threshing floor. The field-bins are constructed like large rectangular boxes with sides formed by the jola stalks, into which the earheads are filled. The bin is then covered with more stalks so that the structure is in the shape of a pyramid or cone very much like an ordinary stack of jola stalks. The stalks themselves are kept stacked in the field until all the mixed crops are also harvested and brought to the threshing floor. The jola earheads are not kept unthreshed for any length of time, like ragi, the threshing starting even before other crops are gathered and brought in.

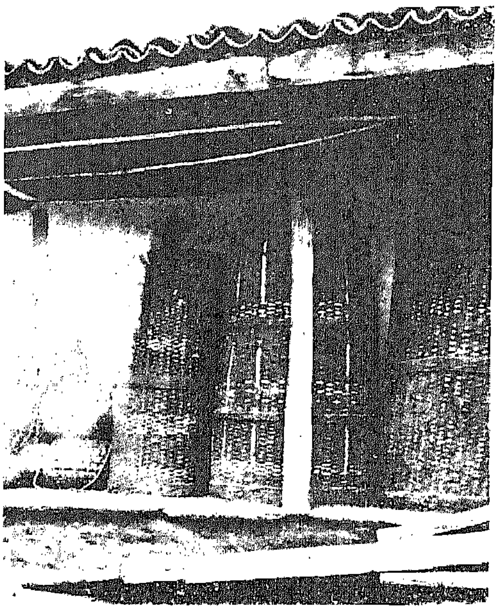
Threshing is by means of the stone-threshing roller already described under 'Rice.' The earheads are spread on the floor in a circular layer about six inches deep and some twenty feet in diameter. Exceptionally large and well-filled earheads are separated and removed for seed purposes and after removing these the layer is allowed to dry till the middle of the day when the threshing work with the rollers begins. Two or three rollers may be used at the same time and the layer of earheads is kept frequently raked over; as the grain becomes separated out it is swept aside, a new layer of unthreshed earheads is made and the threshing continued. The work is continued through the cool hours of the night, as jola is not held in the glumes as tightly as ragi and threshes out easily even if it is not well dried. The threshing by the roller is quick and labour-saving. A day's work for a pair of rollers worked one behind the other is about 15,000 lbs. and this large quantity requires only four men and two pairs of bullocks. Threshing is also done by trampling the earheads under the feet of cattle but this method is too slow and is becoming obsolete. By this method a team of twenty bullocks working for a day will thresh only about 3,000 lbs.

'Hingar' or late season jola.—For the sowing of jola in the late season as a dry crop only black cotton soils are selected

as these alone can retain sufficient moisture for maturing a crop after the rains have ceased. The preparation of the field and the method of sowing are in the manner already described for black cotton soils. The variety sown however is the white jola called 'bilijola', 'yenegar' jola or 'Ibbani' jola in Mysore. These are all early varieties, maturing in less than four months. They also differ from the early and main season varieties in that they have stems which are sweet to the taste and which are not poisonous when eaten by cattle even in the early stages. The grains are also more mealy and are not suitable for storage for any long period as the other kinds.

Hot weather or irrigated jola.—The next jola season is the summer, when jola (called 'besike' jola in Mysore) is grown under irrigation. For this purpose the fields are carefully prepared by ploughing, cultivating and harrowing, the gathering and removal of weeds and stubble and the application of a large quantity of manure. At least ten cart-loads of cattle manure are applied per acre. In these tracts sheep folding is also common, and though costly is seldom omitted. Five herds of 200 sheep each are penned on an acre for a night, for which in the eastern taluks a payment of Rs. 6 is made in cash, in addition to the feeding of the men in charge of the herds and their dogs. After the manure is well worked in, the field is given a light irrigation and plough furrows are made one foot apart from each other in which the jola is sown. The seed is covered by ploughing a furrow between every two rows. Jola is also broadcast in some places and the seed is covered by a light ploughing. The field is now levelled with the levelling board ('koradu'); the board is however so worked that it leaves the field in long beds each as wide as the length of the board, *viz.*, six feet, with a low bund or ridge banked up on either side of the level beds. The field is further laid out suitably for irrigation by putting up low cross-bunds at distances of twenty feet from each other in the beds by opening irrigation channels. The crop comes up with the initial moisture supplied by the irrigation given prior to sowing; it is only after the crop is well above ground that the regular irrigation is given. After three weeks or a month the field is thoroughly weeded and irrigation is given regularly once a week or ten days. In four months the crop matures, and is harvested and threshed in the manner described for dryland jola.

Yield.—In normal seasons dryland jola will yield about 700 to 800 lbs. of grain per acre. On rich black cotton soils with ample rainfall the yield may go up to 1,200 lbs. and in irrigated cultivation to 1,500 or 1,600 lb. per acre. The early maturing varieties like 'yenegar' and 'bilijola' sown in the late monsoon may yield from 500 to 600 lbs. per acre. A Mysore seer of jola grain will weigh between 2 lbs. 2 oz. and 2 lbs. 5 oz. according to the variety and a seer of the fodder jola called 'kakki' jola will weigh

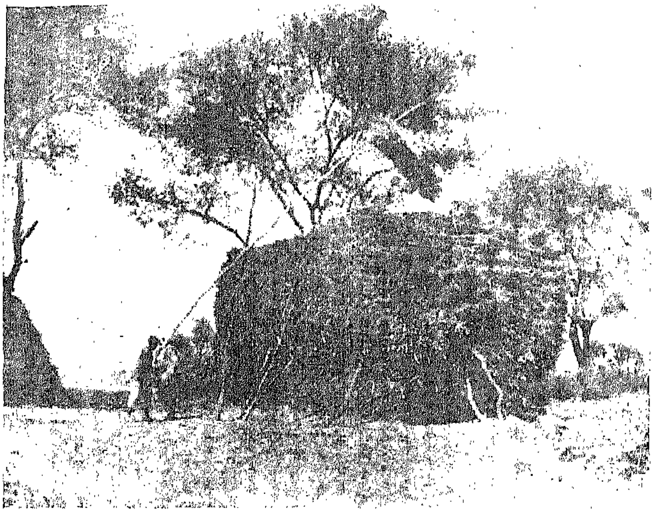


Methods of storing jola and pulses—

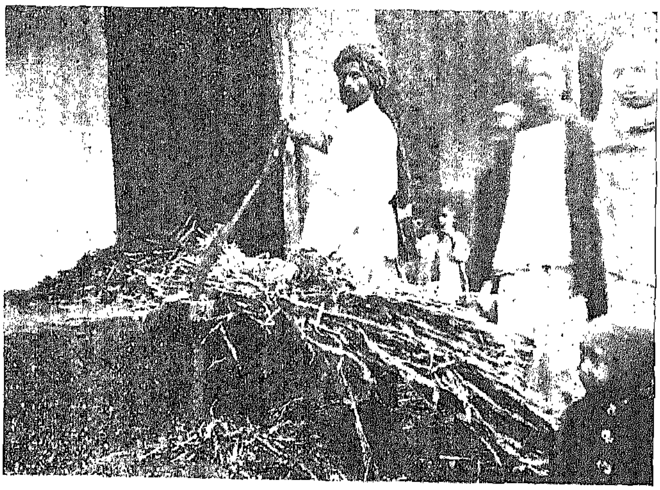
Tall cylindrical bins made of plaited split bamboos, used for storing jola, in Mysore.

Round bundle-like receptacles (on left) made of straw twist, used for storing pulses.

[Photo by Author.



Stacking of jola fodder, showing the *picotah* or see-saw hoist in use.
[Photo by Author.



Cutting jola fodder, using an indigenous type of chaff-cutter.
[Photo by Author.

only 1 lb. 14 oz. The jola stalks form an important dry fodder. The outturn of the stalks may amount to about two tons per acre; well grown crops may yield even double this quantity. A good portion of this fodder is coarse, being made up of the hard rind and pithy stems, much of which is wasted by cattle.

Storage of grain.—Jola is stored in underground pits in the same manner as has been described under 'Ragi.' The grain cannot be kept for anything like the period that ragi can be kept, owing to the trouble with weevil attacks to which jola is very much subject. The storing of jola in sound condition is more difficult than with other grains. Seed has to be preserved by very thorough drying before storage and then preserved covered with a layer of sand in earthenware or metal bins or wicker bins well plastered over with a mixture of earth and cowdung. In a small way seed jola is preserved in the earhead itself, the earheads being tied together and hung from the ceiling in some part of the house, often in the kitchen where the smoke from the cooking ovens is said to keep away insects. Earheads can also be preserved in metal bins or boxes with a little naphthalene. Seed jola preserved in this manner retains its germinating capacity for several years. Irrigated varieties are inferior in this respect to rainfed varieties. The latter can be kept for four years without much loss of vitality. A very small quantity of liquid mercury introduced into the receptacles containing stored grains also prevents the increase of the weevil pest; this method is of course not applicable for grain intended for food.

Storage of fodder.—Jola stalks are kept in large and strongly built stacks put up as soon as the threshing is over. Stacks in the black cotton soil areas are very large structures. They are built upon firm hard elevated ground, with the lower portion of the stack rectangular or square in section and the upper portion triangular. The method of building up the stack is such that it is quite rigid, stands firm and four square and is thoroughly well protected against damage by rain. The sheaves are put in as they are, without being cut, in the lower portion of the stack. They are first arranged across the length of the base, the butt-ends pointing outwards and the top ends pointing inwards, two sheaves meeting in the middle, so that the width of the stack is the length of two sheaves. Over the butt-ends of these sheaves a row of sheaves is arranged lengthwise along both sides of the stack; inside, a second layer of sheaves is laid over the first layer of cross sheaves in such a manner that they lie over the junction of the two sheaves and 'bonding' them together. The process is then repeated by arranging a layer of cross sheaves in the same way as the first layer and on this length the lengthwise sheaves for the sides and the 'bonding' cross sheaves for the middle are arranged. Course by course, the structure is built in this way, an upper layer always 'bonding' the lower until the gable commences. For this part of the stack

the sheaves are cut into suitable lengths, but the same method of construction is followed. Across the stack at each end and against the body of the stack are planted three strong wooden posts firmly driven into the ground which keep the stack well buttressed at both ends. For hoisting the sheaves on to the stack as it rises, ladders are used and the sheaves handed up; or a kind of a see-saw or 'picotah' hoist is rigged up which dispenses with the trouble of men having to carry the sheaves to the top of the stack. This hoist consists of a tall bamboo pole planted by the side of the stack, from near the top of which a cross-pole is slung loosely which can move in a see-saw fashion and one end of which dips on the ground, when the hoist is at rest. By means of a hook fastened to this end the sheaf to be hoisted is attached and by pulling down with a rope at the other end the sheaf is raised to the height required. By moving the power end sideways the sheaf can be delivered at the place where it is required at the top, when the stack builder removes the sheaf and releases the cross-pole for another journey up and down. This is a remarkably simple and clever labour-saving appliance. After the stack is built it is thatched with the dry stems of the 'togare' plant which are stuck into the stack row by row until it covers the top closely from the crest of the gable down to the eaves. With the sharp pitch given to the gable and the layer of thatch as additional protection there is little or no chance of any rain water entering the stack.

Preparing jola fodder.—Unlike other straws, jola fodder has to be cut into pieces before it can be fed to cattle. Fodder cutters of the ordinary chaff cutter types are not considered suitable as it is believed that the pieces are cut too small and the sharp ends prick into the tongue and mouth of the cattle which therefore waste a good portion. Fodder is therefore cut into lengths of a foot or a foot and a half by ordinary long-handled large curved knives or by local types of chaff cutters which have straight blades with a long handle working up and down nut-cracker fashion. Owing to its coarseness the fodder is usually softened by soaking in water before it is fed but even then a good deal of the stems is rejected by the animals.

Green jola fodder.—Jola is the most important crop grown for green fodder and indeed may be said to be practically the only crop grown exclusively for fodder. Jola intended for fodder is grown either in separate fields as the sole crop or, as has already been referred to, along with the grain jola as a mixed crop, and along the margins and as a mixed crop in ragi, groundnut and other crops. Fodder jola is grown both as a dry crop and to a lesser extent as an irrigated crop. The varieties of jola grown for fodder are different from the ordinary ones and comprise several kinds, called 'kakki' jola, 'vogar' jola, 'irungu' cholam, 'sundhia' jowar, 'nilwa' jowar, and so on. If grown under irrigation the soils are heavily manured and large yields of

fodder are obtained. When grown as a dry crop by itself, fodder jola is one of the very early sown crops, and after it is cut the field is ready for another crop in the same year, which is usually horsegram. Seed is sown very thick, by broadcasting and ploughed in. In sixty to eighty days the fodder is ready to cut. As much as 60 lbs. of seed are sown per acre and the crop comes up very close with tall thin stems which are eaten by cattle without any being wasted. Yields under irrigation are heavy and may amount to between ten and twelve tons an acre of green fodder. Grown in the midst of ordinary jola or other crops, the fodder jola is cut when the earheads have just appeared. It is generally risky to feed jola to cattle before this stage, unless it is dried somewhat after cutting and then fed. Similarly young jola which has suffered on account of drought is also risky to feed. The plants in the immature stage contain prussic acid which proves fatal even in very small quantities. Under certain conditions of weather and of growth, which are not well understood, the prussic acid content reaches a dangerous limit, as much as 0·2 per cent being found. *If the jola is cut and then dried in the sun or if it is converted into silage, the acid content goes down and the fodder is rendered safe.*

Green jola becomes available for feeding from the month of September on these fields. The stalks are generally fed whole without being cut or chaffed. It is also the practice in Mysore to feed much larger quantities of this stuff than what the animals will care to eat ordinarily, by cramming or a kind of forcible feeding, in which the stalks are thrust into the mouth of the animal and slowly pushed in until the whole has been eaten. Animals are thus brought into very good condition—perhaps an overfed condition, because their flanks become stretched tight as a drum—by the time the green jola season comes to an end which synchronises with the time for the great cattle fairs in the State. Chaffing the stalks in regular chaff-cutting machines is however, very common in Upper India.

The grain from the typical fodder jola varieties is thin and poor in quality as a food grain for which purpose it is not used. For seed purposes some rows are left uncut until they mature seed and are then harvested.

Some varieties of jola will send out new shoots from the harvested stubble and yield a small ratoon crop especially on the black cotton soils which retain sufficient moisture for the growth of this ratoon crop. More than one shoot springs from each stubble which grow four or five feet high and yield a certain amount of green fodder even if they do not mature seed.

Botany and varieties.—Jola—*Andropogon sorghum*,—also known as *Sorghum vulgare*—belongs to the natural order Gramineae. It is a tall annual grass, with a robust solid pithy cylindrical stem and attains a height of ten or even fifteen feet according to soil and variety. The stem may be thick, about

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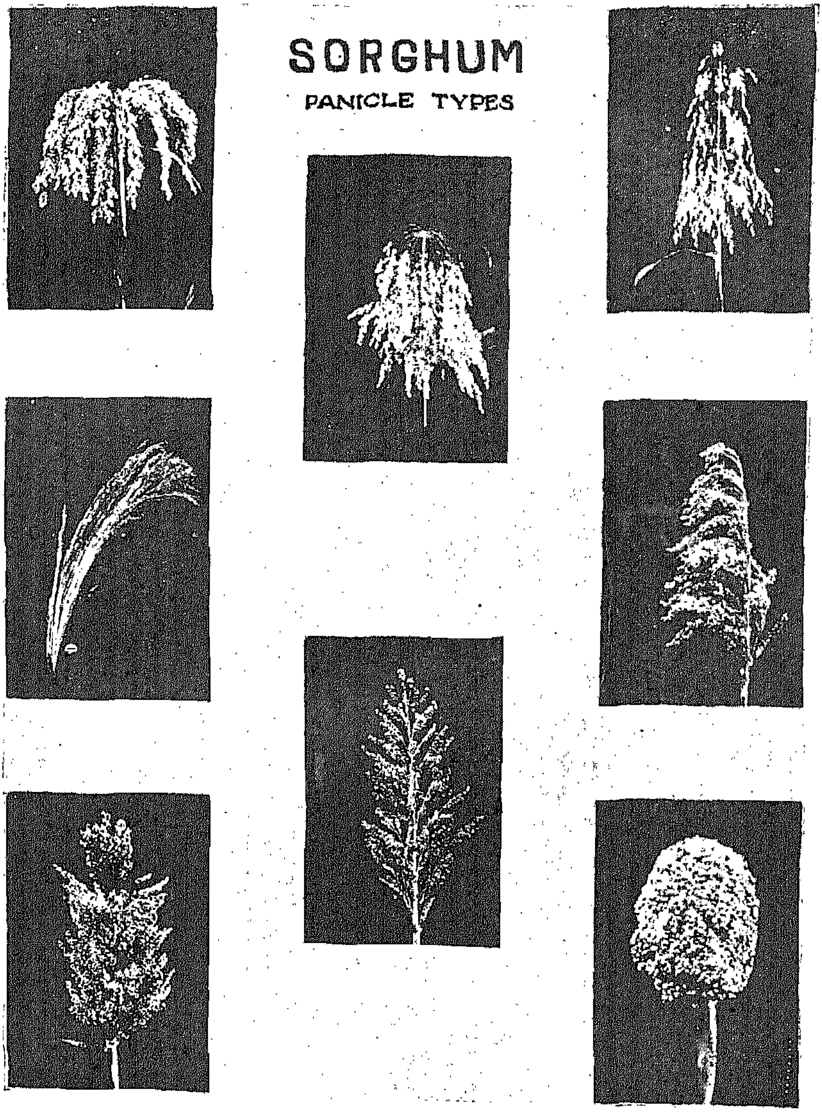
1 to 2½ inches in diameter, or thin and about only half inch in diameter and even less, if sown very thick. The root system is fibrous and profuse and some of the lower nodes send out roots which are mostly aerial but also sometimes reach the ground and function as true roots. The leaves are about 2 to 3½ feet long and from 1 to 3 inches broad, with a conspicuous midrib which is white in colour in contrast with the green of the blade, and are smooth except at the margins which are rough. The inflorescence is a panicle which is compact, semi-compact, loose, or very open according to variety, and likewise varying in shape which is cylindrical, ovoid, or rounded. The peduncle is 1 to 2 feet in length and erect or "goose necked". The panicle is highly branched with branches and branchlets springing in whorls from the stem of the panicle. The rachis is either equal to or less than one half the length of the panicle, according to variety. The panicles vary in length from 6 inches to 2 feet according to variety. The spikelets are in pairs, each one-flowered, the lower sessile and hermaphrodite and the upper pedicelled and male. The flowers open from the top of the panicle and extend downward gradually, taking about eight days to finish. The glumes are four in number, white, yellow, brown, dark brown, reddish brown, or black in colour with the last glume sometimes with a short awn. The grains are formed clear of the glumes and are rounded, pointed at the base and have a slight depression near this end. The seed coat is thin, or thick or hyaline or horny. In certain other types the glume encloses the seed either completely or to a great extent.

The cultivated jola comprises a large variety of types which are classified into several sub-species. Many methods can be adopted in classifying as there are sharp differences among the types. They can be divided according to the seasons to which they are suited, as 'mungar', 'yedegar' or 'hingar'; they can be classified according to the structure of the earheads as some are loose, some compact, some semi-compact; and again according to the shape which comprises ovoid, elliptical, rounded, or goose-necked; they may be classified as the grain sorghums, fodder sorghums and the sweet sorghums. The colour of the glumes is varied and so is the colour of the grains. These are yellow, cream coloured, white, purple and almost black, brown, orange and deep brown. The vernacular names by which the varieties are known are descriptive of the colour of the grain, such as yellow jola, red jola, white jola, etc., or of the season as 'mungar' or 'hingar' or 'ibbani'; or as a grain jola or a fodder jola like 'kakki' jola. In America the varieties are broadly classified as the pithy-stemmed and the juicy or semi-juicy-stemmed kinds, under each of which many differences exist in respect of the colour of the grain or the shape and size of the earheads. According to the character of the panicles and their branching the Indian sorghums have been divided by Gammie into seven sub-species.



Shapes of the earheads in the different varieties of Jola.

[Photo by courtesy of the Millets Specialist, Coimbatore.

Bag for catching grasshoppers—an improved type designed for moving on wheels.
[Mys. Agri. Dept.

Pests and diseases.

(*a*) *Insect pests.*—Jola is subject to several insect pests and diseases. When the crop is young the grasshopper and caterpillar pests are severe and sometimes wipe out the crop altogether. The grasshopper pest—*Colemania sphenereoides*, *B.*—which has already been referred to under ragi is particularly severe in the jola crop; several broods come out as the crop grows, and the attack is continuous. It is however when the crop is young and has only a few leaves that the defoliation is too severe for the plants to survive. Unfortunately the emergence of the pest coincides with or just precedes the main sowing season of the jola crop, *viz.*, the months of June and July, exposing the young crop to the full force of the pest. The pest is confined to particular areas and seems to occur at ten-year periods more or less in a regular cycle and it is therefore possible to be somewhat forewarned. Among the remedial measures the best so far known is the dragging of special grasshopper traps or bags over the field and then destroying the hoppers which are caught in large numbers in these bags. A large-sized bag constructed suitably for being dragged mounted on a low-wheeled frame is recommended for large landholders and for co-operative use by small holders.

The Caterpillar Pest—*Amsacta albistriga*, *M.*—also attacks the crop and is very destructive to the young crop. The pest has been referred to and the remedies described under 'ragi'.

As the crop grows up it is subject to the attacks of stem borers, as the result of which the top shoot dries off. The pest is not serious and often the damaged plants send out one or more side shoots, and generally withstand the attack.

A very serious pest in some years is the jola earhead bug, or fly—*Calocoris angustatus*, *L.* The earheads are attacked when they are young, and the contents of the young grains and the sap from the tissues of the earheads are sucked and drained by these innumerable insects, and the setting of grain is prevented. Earheads are often completely empty and most are very nearly so. The ground under the plants becomes also black and sticky with the exudation. The damage is very great and in the years when it does break out it is also widespread. The pest is serious on the early sown jola and both the late sown jola and later formed earheads are generally free. No satisfactory method of control is known, but at one time it was suggested that cloths or mats smeared over with some sticky paste such as is used for catching flies and called 'tangle foot,' 'catch'em alive' and so on, should be moved about just above the tops of the jola crop, the idea being that when the bugs (also called flies) are disturbed they fly upwards and are caught in the paste. It is found however that all flies do not fly upwards and that a good lot of them drop down and escape the trap.

Aphids also cause much damage and oftentimes fields are severely infested, leaves, stems, and young earheads being alive with these insects which drain the sap and arrest the growth of the crop. In comparison with the earhead fly or bug this is a minor pest.

No large scale remedies are known, but the pest disappears if a good shower of rain is received.

Storage Pests.—Jola grain is damaged a great deal in storage by weevils of which both the larvæ and the adults eat into the grains and reduce them to a hollow shell. In addition to the destruction of the grain is the very presence of innumerable weevils which teem in the grains making it unfit for consumption unless the grain is thoroughly cleaned and the weevils completely got rid of. It is impossible to preserve the grain in ordinary bags without its becoming infested very soon by the weevils. Storage therefore requires special care. One method consists in first drying the grain thoroughly in the sun, cleaning and then putting into earthenware or wicker bins, well plastered over to prevent the ingress of weevils. The top of the grain in the bin is covered over with a two-inch layer of sand and the mouth of the bin then covered by a lid. Grain as required is drawn out through a suitable aperture or trap door at the base of the bin. The breeding of the pest in the grain is prevented by the fact that such weevils as emerge crawl up through the grain and on to the top of the layer of sand for pairing but are not able to crawl back through the sand for oviposition and multiplication. This simple method is found very effective and is to be adopted not only in the case of jola but also for other grains and all the pulses. Jola is also attacked by the rice moth, the larvæ of which destroy the grain in the same way as they destroy stored rice.

(*b*) *Diseases.*—The jola crop is subject to many fungus diseases as well. The chief among these are the 'smuts' of different kinds, *viz.*, (1) the grain smut, *Sphaceolotheca sorghi*, (2) the loose smut, *Sphaceolotheca cruenta*, (3) the head smut, *Ustilago Reiliana* and (4) the long smut, *Tolyposporium filiferum*. By far the most serious is the grain smut in which the earheads are attacked and the grains are reduced to sacs of black powdery spores of the smut. The infection comes from the spores adhering to the seed and the remedy is therefore fortunately simple. The method of treating the seed before sowing has already been described under 'sowing methods.' In the case of the head smut the whole earhead is affected and such earheads emerge as a black mass of tangled filaments. The disease is spread by spores which are shed on the soil and which remain alive and capable of germination at the crop season. Seed treatment is therefore of no use against this smut. But neither this smut nor the long smut is widespread; they are also only of rare occurrence.

Another malady which is very often seen in jola is the appearance of red spots on the leaves, a reddening of the leaves

and the inside of the stem as is seen in the 'red rot' disease of sugarcane. The attack is due to the fungus 'Colletotrichum graminicolum' and results in a partial drying up of the leaves and a general unthrifty growth. There is certainly a reduction in the yield to that extent but this is seldom taken note of. Another fungus disease, *viz.*, *Macrophomina phaseoli, Maubl.*, has been reported as somewhat serious in Gujarat and the Bombay Deccan, especially in jola sown in the late season. It is said to be favoured by a high moisture content in the soil accompanied by a high soil temperature also.

Vegetable Parasite.—Jola also suffers from the attack of some vegetable parasites, the most serious of which is the '*striga.*' The attack is rather serious in certain villages where it is a yearly visitation. The *striga* parasite grows with its roots intertwined with the roots of the jola, depleting it of its nourishment and thereby arresting the growth and reducing the yield. At least three species of the *striga* are known to attack jola but individual peculiarities, if any, of these species which may necessitate any difference in the methods of eradication applicable to each are not known definitely. The *striga* grows near the base of the jola, and eventually flowers and sets seed, which shed in the field and perpetuate the pest. A change-over to other crops like groundnuts, cotton, coriander and so on for two or three years is recommended as a control measure sometimes, but the *striga* seeds appear to retain their vitality for many years and to germinate and grow when jola is cultivated again. Systematic and thorough removal of the *striga* plants before they flower and set seed will greatly reduce the chances of this perpetuation. The *striga* makes its appearance after the weeding by bullock hoes is finished; even otherwise they cannot be easily removed by bullock hoes as they are too close to the jola and too firmly bound to their base. Only hand weeding, costly though it may be, can remove them satisfactorily. Another method suggested is to grow a crop of jola or ragi, and thus encourage the *striga* to grow also and then plough down both crop and pest before the latter is due to flower. The pest in some places is certainly bad enough to warrant this drastic and rather expensive method of control.

Another parasitic flowering plant—*Supobia delphini polia*—is also reported to attack jola and to cause considerable dwarfing of the growth of the crop.

Chemistry and uses.—The jola grain is eaten either by breaking the grain and cooking it in the same way as rice or by grinding it into flour and preparing unleavened bread out of it. To a small extent it is eaten parched and some varieties yield grain which can be converted into 'popped' grain. Such grain after popping is eaten as such or ground into flour. The varieties which lend themselves to 'popping' are those with the open branched earheads and not those with the compact heads. The

grain of the former is comparatively smaller in size and the endosperm is hard and horny towards the periphery, the centre alone being mealy. Jola can also be malted. The malted flour is prepared by steeping the jola grain in water overnight, draining the water out, and then keeping the grain moist and heaped up until sprouting begins and the radicles are plainly visible. The grains are then spread out to dry, are rubbed free of the radicles when quite dry, and then roasted and ground into flour.

The chemical composition of the jola grain of different kinds and of jola dry fodder is as follows:—

	Grain I	Grain II (White)	Grain III (Red)	Dry fodder	
				I	II
Water ...	12·5	12·0	12·1	7·4	8·7
Albuminoids ...	9·3	7·1	9·9	2·4	2·1
Carbohydrates ...	72·3	74·4	71·5	46·2	39·7
Fat ...	2·0	3·1	3·2	2·1	1·5
Crude fibre ...	2·2	1·4	1·2	31·4	39·8
Ash ...	1·7	1·9	2·1	10·6	8·4

Sweet or Sugar Sorghum.—Among the varieties of jola one of the most interesting is the sweet sorghum. Under its other names of Durra, or Guinea corn the sweet sorghum is cultivated in Africa, Australia, China, the West Indies, and the United States. In India the cultivation is rather insignificant. In the Southern States of the U. S. A., it is of considerable importance, being looked upon as a source of sugar. The juice of this sorghum may contain about 10 to 13 per cent of sucrose, and the total sugar content, consisting of both sucrose and glucose may reach 18 per cent. The sorghum matures to this degree of sweetness in about five months. At one time sugar of high grade was being manufactured on a factory scale in that country and the crop was considered a valuable supplement to sugarcane. The manufacture of treacle, molasses, syrup and other liquid or glucose sugars is however the use to which it is largely put. It is also largely grown for the sake of the sweet nutritious fodder which it yields quickly and in great abundance.

Production.—Next to rice and wheat, jola is the food grain grown over the largest area in India. The total area under jola in the whole of India was 34,635,000 acres, made up of 20,702,000 acres in British India and 13,933,000 acres in the Indian States. The major areas are as under:—Hyderabad State, 8,565,000; Bombay, 8,100,000; Madras, 4,600,000; the Central Provinces, 4,200,000; The Punjab, 800,000; and Mysore, 667,000 acres (all figures relate to the year 1937-38).

IV. SAJJE (Pennisetum typhoideum).

VERNACULAR NAMES FOR SAJJE—*Kannada*-SAJJE; *Tamil*-KAMBU; *Telugu*-SAJJALU, GENTALU; *Malayalam*-KAMPAM; *Hindustani*-BAJARA.

Sajje.—The 'bullrush millet,' Pennisetum typhoideum—is one of the most important among the millets or small grains and is only next in importance to jola among the minor food grains for large sections of the world's population. Outside Asia, the grain is largely cultivated in Africa where it is a common article of food among both the Arabs and the natives. It is grown throughout India and in the United Provinces, Oudh, in the Madras and Bombay Provinces and the Hyderabad State over very large areas. In the Bombay Province the grain ranks equal to jola in importance, with almost an equal acreage, *viz.*, about 5½ million acres. In Madras the acreage is about 3½ million acres approximately while in Hyderabad it is about 2⅙ million acres. In Mysore the grain is only of minor importance the area ranging between 700 and 1,000 acres.

The crop is suited to regions of low rainfall and can be grown in tracts with only 17 or 20 inches. It is seldom grown under rainfall heavier than about 35 inches. In the eastern taluks of Mysore where the rainfall goes down to some 17 inches it is a favourite crop for being grown in the manner peculiar to this tract where a fallow, of one year at least and often of two or three years, intervenes between two crops. It will thrive under conditions of soil and rainfall which may not be good enough for jola.

Soils.—'Sajje' is grown both on the black cotton soils and on the various grades of red and grey sandy soils, and on good soils with depth as well as on light coarse and gravelly soils. On the black cotton soils and on the better class of red soils, deep and free from gravel and stones, the growth is luxuriant and on the inferior types only moderate. It is grown mostly as a dry crop in the rainy season and to a small extent under irrigation under garden cultivation in the same way as irrigated jola or ragi, generally as a hot weather crop.

Rotation.—'Sajje' is grown both as a pure crop and also with a variety of mixed crops, as in the case of jola. When grown pure it is followed in the same year with horse-gram, in the regions where rainfall is early and the 'sajje' can be sown about the month of May. Where sajje is the sole crop of the year, cotton and jola follow it in the next two years either as 'sajje'-jola-cotton or 'sajje'-cotton-jola. On the red soils a 'sajje' crop may follow ragi, although the former is not a crop grown every year like ragi. On the rough coarse gravels and red soils castor may follow sajje.

'Sajje' as a main crop is almost invariably grown with the usual mixture of some pulse crops. The common mixed crops

are 'togari', 'avare', and horse-gram. The first two are sown at the same time as the sajje and the third is sown simultaneously with the sajje if the season is late, or later on in rows in the young growing crop of 'sajje'.

In the black cotton soil districts, whether the sajje is grown on black soils or on red soils, a variety of mixed crops are grown, as already described under 'Jola' which comprise one or more of the following :—'togari', 'avare', green-gram, black-gram, horse-gram, 'gingelli', 'pundi' and so on. In irrigated garden cultivation, one or other among the varieties of both grains and other crops follow sajje.

'Sajje' can be sown as an early crop in the rains about the month of May, and as a main season crop about the beginning of July and even early in August. The irrigated garden crop is sown in January and February.

Cultivation.—The preparation of the field for 'sajje' is somewhat thorough, although it may not equal the tilth attained for ragi. If the field had not been ploughed after the harvest of the previous crop, ploughing commences with the very first rains, and is repeated after every subsequent rain; cultivators or bladed harrows may be used and the work expedited; the field is manured with some five cartloads of manure as for ragi. Immediately after a sowing rain is received the sajje is sown broadcast and a plough or a cultivator worked to cover the seed. At intervals of about six feet, furrows are made with a plough in which a mixed crop, generally, 'togare', is sown and covered by ploughing an adjacent furrow. After about three weeks the first hoeing is done with bullock hoes with two or three hoe points. The hoeing is repeated after ten days, the hoes being worked this time across the direction of the first hoeing. The early variety of sajje matures in three months; there is considerable tillering of the crop and the earheads appear and ripen irregularly, and the harvesting is therefore carried out twice or thrice at intervals of about ten days and completed in about four months. The earheads are removed to the threshing floor, dried and threshed within a week after the harvest. The stalks are cut and stacked for fodder.

For the main season sowing, the fields are ploughed after the soil has received good soaking rains, generally about June—July. If the soil is of the black cotton soil type, the ploughing is dispensed with and the field worked lengthwise and crosswise with a heavy bladed harrow; on other soils the field is first ploughed and then worked with bladed harrows, an interval of a week or two being allowed to elapse for the weeds to come up so that they could be destroyed by the harrowing which follows. Manure is seldom applied in practice but the crop certainly responds well to manuring. As a matter of fact in the tracts referred where the 'sajje' is grown after two or three years of fallow, the field after the first two ploughings is manured by the

penning of sheep. Sowing is generally about the middle of July after good rains have fallen. The field is now worked with the light bladed harrow and the 'sajje' is sown through the three tyned seed-drill, which sows in rows about a foot or fourteen inches apart; after every fifth row comes a row of the mixed crop or crops selected for sowing from among the number mentioned already. Seed is covered by the light bladed harrow. After three weeks the field is worked with bladed interculturing hoes between the rows of the crop, and a second hoeing is given again in another ten days, after which no further weeding or cultivation is given. The crop matures either in four months or five months according to the variety sown. Harvest consists in cutting off the earheads, which are removed to the threshing floor and threshed either by trampling the earheads under the feet of a team of oxen or by using the stone threshing rollers.

In parts of Madras a short duration variety called 'Arisi Kambu' is grown. The peculiarity of the grain is that it husks freely at threshing time and requires no further husking like the other varieties. It is also sown about the month of July on land well prepared and manured. The seed is sown broadcast and ploughed in. The weeding and interculturing are also done by means of ploughs; the land is worked with light ploughs about fifteen days after sowing and once again in another fifteen days, but this time in a direction across the first ploughing. The crop matures in three and a half months and the grains are reputed to keep for many years. The crop is grown on light sandy soils, which are considered more suitable to this variety than red clay loams or black cotton soils.

The seed rate for 'sajje' when raised as dry crop is about six to eight pounds per acre. The seed is sown either by itself or mixed with manure.

'Sajje' is cultivated as an irrigated garden crop on soils well prepared and manured. The cultivation is carried out in much the same way as irrigated jola which has already been described.

Yield.—The yield of 'sajje' under dry cultivation, under favourable conditions amounts to 700—900 lbs., per acre, but ordinarily amounts to only about half this quantity. Under irrigation 1,000—2,000 lbs., of grain is obtained. A Mysore seer of the grain will weigh two pounds.

The dry stalks or straw of sajje after harvest are not much esteemed as fodder; the stems are too coarse and pithy and are generally used for thatching or purposes other than for fodder. The leaves alone are eaten by cattle. Though on this account the sajje straw is considered very inferior fodder generally, there are tracts like Gujerat where the contrary opinion prevails and the fodder is a favourite feed.

'Sajje' is a crop well suited for cultivation for purposes of green fodder. It is quick growing, tillers very freely and in the

case of some varieties the stems are very thin and succulent. It also lends itself to cutting more than once, as a large number of tillers spring from the stubbles. As a matter of fact in many parts of India it is an important crop for green fodder.

Botany and Varieties.—'Sajje'—Pennisetum typhoideum—belongs to the natural order Gramineæ. It is an erect tall growing grass from three to eight feet in height according to variety and fertility of the soil. The stems are solid and usually single, but often there are branches both primary and secondary and sometimes even tertiary. The plants tiller freely and give much leafy fodder. The leaves are long and lanceolate with ligules densely hairy. The stalk of the inflorescence is highly hairy with soft woolly hairs. From the lower nodes much ærial rooting takes place as in Jola. The inflorescence is a rounded long cylindrical spike densely packed with the spikelets. These are in clusters of one to eight on separate pedicels; the bristles vary in colour and are only as long as the spikelets except in the awned varieties where one bristle or awn is much longer. The spikes are of varying lengths and thickness and are smooth or awned according to the variety. The spike in the main cultivated varieties is about 9″ to 12″ in length and 1″ to 1½″ in diameter. They are either greenish yellow or have a slight pinkish tinge according to variety.

The local varieties may be said to be the following:—(1) the 'hullu sajje', in which the stems are very thin, there are numerous tillers and the spikes are short and thin. The variety is largely esteemed for the sake of its green fodder; (2) the common 'sajje' which grows about six to eight feet in height, has a thick stem, tillers little, and has a spike about 12″ in length, smooth and either greenish yellow or pinkish in colour; (3) the 'mullu sajje' or the awned 'sajje' which is much like the second variety, but is highly awned. This variety is esteemed for sowing in distant fields, as it does not require to be watched against havoc by birds on account of the awns which are stiff and are almost thorny; (4) a recent introduction is the giant or Transvaal 'sajje', in which the spike is about 18″ to 22″ in length and about 2″ in diameter. This variety has a tendency to yield spikes which are never well filled, there being large bare patches. It is more spectacular than useful; (5) the variety called 'Arisi kambu' in which the grains do not require any husking has already been referred to. It is more or less a curiosity and the yield is comparitively low. Extremes in presence and absence of bristles (or rather, forms with one prominently developed awn and those with all bristles suppressed) are represented by two species, *viz.,—the P. echinurus and P. leonis.*

Pests and diseases.—'Sajje' is subject to two omnivorous pests, *viz.*, the red headed hairy caterpillar—*Amsacta albistriga*—and the Jola grasshopper—*Colemania sphenoreoides*—in the tracts where these pests prevail. The remedial measures have

already been described under Ragi and Jola. The black headed hairy caterpillar, the plant bug—*Nezaria viridula*—blister beetles, etc., also attack the crop but are very unimportant.

'Sajje' is subject to the smut, '*Tolyposporium filiferum*,; the grains in the earheads are either completely or partially attacked; the smutted grains are conspicuous by their comparatively large and swollen size and crumble into the characteristic black powder when pressed. The remedial methods adopted for other smuts *viz.*, treatment of the seed with copper sulphate solution, formalin or hot water, do not succeed with this smut. The only remedy appears to be to avoid growing sajje in fields once affected, for a period of two or three years.

'Sajje' is subject to a peculiar malformation of the earhead in which the floral organs turn into leafy growths instead of functioning normally and setting seed. Though by no means serious, it is not altogether negligible as quite a large number of earheads are met with in many fields. The trouble is due to the attack by a fungus—*Sclerospora graminicola*—which is known to attack other grains also such as jola and 'navane'. The only way it could be kept down is by removing and burning the infected plants and thereby preventing further infection. 'Sajje' is also subject to a leaf rust which is however insignificant as regards damage.

'Sajje' is also peculiar in the uneven setting of seed in the earheads. It is not every earhead that is well filled from top to bottom; a large number are met with which are only partially filled; it is probably due to the seasonal conditions at the time when the florets open and are due to be fertilised. There is no doubt that this condition brings about a material reduction in the yield.

Uses and Chemical Composition.—The grain has to be husked like rice before it can be used for consumption. The husk however forms only a very small proportion of 8 to 10 per cent of the grain. The variety called the 'Arisi Kambu' needs no husking. The grain is eaten generally cooked like rice. It is also ground into flour for consumption and prepared as a mash or as unleavened bread. The grain can be fried and ground and the flour used somewhat like malted flours.

The chemical composition of 'sajje' grain showing its value as food is as below :—

	Water	Albuminoids	Carbohydrates	Fat	Crude fibre	Ash	
Sajje grain ...	11·8	10·4	71·5	3·3	1·5	2·0	Church
do ...	11·0	8·6	74·7	5·8	0·9	1·8	Leather
do ...	12·4	11·6	67·1	5·0	1·2	2·7	Aykroyd
Straw ...	7·07	1·94	43·9	1·3	37·6	8.04	Wood
Green fodder cut in milk stage (in dry matter).	...	10·56	50·1	2·1	27·9	9·2	K. C. Sen.

V. NAVANE (Setaria italica.)

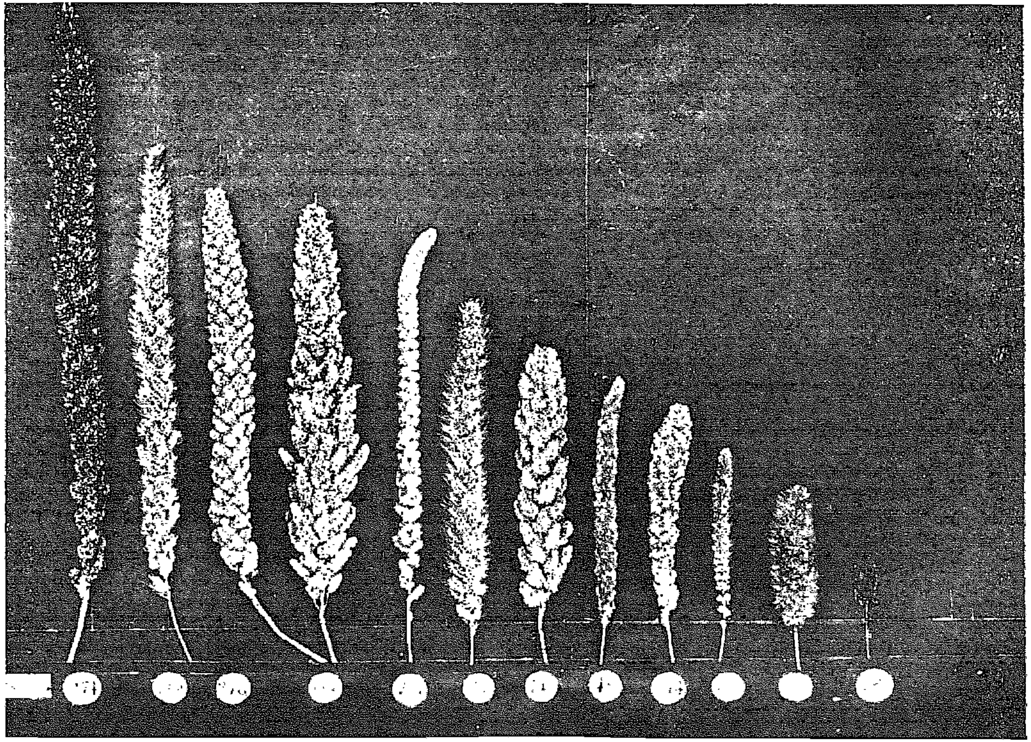
VERNACULAR NAMES FOR NAVANE :—*Kannada*-NAVANE, *Tamil*-TENAI, *Telugu*-KORRALU, *Malayalam*-TENA, *Hindustani*-KANGOONE.

'Navane' is one of the minor dry land food grains which comes to maturity within a period of about a hundred days and at the same time gives almost as good a yield of grain as the food grains which occupy the ground for a much longer period. It is also suited to tracts of low rainfall. Large areas are grown in Madras and Bombay and in Mysore too it is a crop of considerable importance next only to ragi and jola. The grain is said to be capable of cultivation even at high altitudes of about 6,000 feet, and to be an important food grain grown in the foot-hills of the Himalayas. It is also grown in many other parts of the world, such as China, Japan and Eastern Asia generally, South Africa, Southern and Eastern Europe and in North America, and has thus a wide range of cultivation. It is essentially a dry land grain and suited to conditions of low or moderate rainfall ranging from 20 inches to about 30 inches.

Soils, rotation.—It is grown on a variety of soils. The ordinary red loams are much favoured and under normal rainfall very good crops are raised on such soils. Very light soils, ashy grey types and black cotton soils are all put down to navane. On the black cotton soil it forms an important grain crop, ranking next to jola. Even on the heavier clayey type of soils usually put under rice, 'navane' is cultivated as a dry crop in tracts of uncertain rainfall. The crop can be grown throughout the year, as a crop for the early rainy season, for the main rainy season and for the late rains and again in the hot weather. As a minor grain crop, 'navane' therefore should be considered a very useful crop.

The crop is grown pure without a mixed crop or it is grown as a subsidiary mixed crop with ragi, or to a large extent as a mixed crop with cotton. On red soils 'avare' is used to sow as a mixed crop with 'navane'. It is usually followed by jola, or 'sajje' in the next year, these latter being grown with their appropriate mixtures. When 'navane' is grown pure it is generally followed by ragi or by jola and when grown with cotton it is followed by jola.

Cultivation.—All soils intended for 'navane' receive thorough preparation; in the case of all but the black soils, two or more ploughings followed by working with the cultivators or bladed harrows, gathering of weeds and cleaning up and levelling with the light harrows or levelling boards are the operations preparatory to sowing. In the black cotton soils one or two



Earhead types in different varieties of Navane.
[Photo by the Millets Specialist, Coimbatore.

The Stone Threshing Roller, which is used for threshing ragi. jola, rice (in the Malnads of Mysore), and almost every other pulse. [Mys. Agri. Dept.

harrowings with the heavy-bladed harrow take the place of the ploughings and are followed by working with the light-bladed harrows before sowing the seed. Manures are seldom applied on the black cotton soils but on the other types and especially where the crop is grown under irrigation the fields are manured with about five cart-loads of cattle manure per acre at least. The crop will however respond greatly to manuring and more liberal doses can be used with advantage. This is indeed the case with irrigated 'navane' which is well manured with either cattle manure or sheep penning or both. In some parts of Mysore even dryland 'navane' is occasionally given a small dose of artificial manure of about one cwt. per acre of sulphate of ammonia, which is drilled along with the seed. The crop is sown both broadcast and in drills. The sowing season for the early crop is in the month of May, for the main rainy season crop the month of June—July and for the late crop August-September. The irrigated hot weather crop is sown in January-February. When the seed is sown broadcast it is usual to divide the field into long strips of ten feet wide by means of shallow plough furrows, sow the strips one after the other and then cover the seeds by a light ploughing. By this method uniform sowing is secured over the whole field. If sown as mixed crop with ragi, the 'navane' is sown in single or double furrow made by the plough at intervals of about six feet, after the ragi has been sown. Where drill-sowing is the practice the three-tyned or six-tyned drill is used and five rows of 'navane' are made to alternate with one row of cotton, by plugging the last hole in the six-tyned drill and sowing the cotton seed through a 'sadde' seed-tube behind this tyne, or where the three-tyned drill is used by plugging the third hole and sowing the cotton in the same way, at every second journey. After the field is sown the seeds are covered by working a light-bladed harrow. In tank-fed areas 'navane' is sown as a monsoon crop, *i.e.*, sown in the months of June-July, if sufficient rains are not received in the season to allow of rice being cultivated. These fields are ploughed from March to May, cattle manure applied or sheep penned and after ploughing in the manure the field is sown broadcast or in drills about the month of July. The seed rate per acre is from 7 to 10 lbs. of seed, the latter being the rate for the pure crop and the former for the mixed sowing with cotton. Where it is sown as a mixed crop with ragi about 1 to 2 lbs. are sown. The crop is hoed once after a fortnight following the sowing with the interculturing bladed or toothed harrows and then allowed to grow without further attention. The crop is ready for harvest in three or four months according to variety. The crop is thin-strawed and attains a height of some three or three and a half feet. The earheads which are some six to nine inches long bend down a great deal and are likely to be knocked about. This is especially the case

with the variety called 'Jade Navane'. Harvesting is by the cutting off of earheads alone; the stalks are either cut or pulled out later on. The earheads are kept piled up in the threshing floor for a week and then threshed out by trampling under the feet of oxen or by using the stone threshing roller. The straw is thin and delicate and cattle can eat it without its being bruised or softened under the roller or the feet of oxen.

Irrigated Navane.—'Navane' is also grown under irrigation as a garden crop on well drained loamy soils. The field for this purpose is prepared in the months of October and November. The fields are lightly watered, and ploughed twice or thrice at intervals of two weeks. Cattle manure is then applied or sheep folded on the land, the field is again ploughed or worked with the bladed harrow and the seeds are then sown broadcast. The field is now laid out into suitable beds for irrigation, which is given once in a week or ten days till the crop matures. Weeding is by hand and is given twice during the early stages of the crop.

Yield.—The yield of 'Navane' grown pure by itself is generally between 800 and 900 lbs. per acre on an average and may go up to 1,200 lbs. under favourable conditions. Grown as a semi-irrigated or garden crop the yield may go up to 1,600 lbs.

Botany and varieties.—'Navane' —*Setaria italica*—is an annual grass attaining a height of 3 to 3½ feet with rather thin leafy stems which bend down a great deal with the weight of the earheads. The leaves are narrow and are about 12 to 18 inches long and ½ inch broad, light green in colour, linear lanceolate in shape; the flag has a long sheath with the blade either shorter or longer than the inflorescence. The peduncle is long and slender; the inflorescence is a spike, which is long and drooping. The spikes may be 6 to 12 inches long and ¾ to 1½ inch in diameter, and covered over with thin bristles. The branches in the spike are arranged spirally along the length and the spikelets are in clusters of 40 or 50. Only the fourth glume contains a bi-sexual flower which ripens a grain. The glume with its pale is fused on to and forms part of the grain. Many varieties are under cultivation which differ in the height they attain, in the length and appearance of the earhead and in the colour of the grain. Varieties are also different in the duration of the crop, varying from three to four months in this respect. The plants may grow from 3 feet to 4½ feet in height. The earheads are short, about 6 inches in length, and may go up to 12 inches according to variety. The earheads are compact and comparatively smooth or are long, lax and with bristles, and from ¾ inch to 1½ inches in diameter. The grains show a great variety in colour, being smooth and shiny and coloured yellow, white, cream coloured, orange red, purple, black, greenish white, buff and so on. Varieties are given names which are generally descriptive of the colour and appearance of the earhead.

Pests and diseases.—The insect pests which are common on ragi, jola and 'sajje' also attack navane and the remedial measures are the same as have already been described under these crops.

Navane is subject to the "green ear" disease—*Sclerospora graminicola*—mentioned under 'sajje' and is often badly damaged as the result. The remedies are the same as already described. Navane is also subject to a smut—*Ustilago crameri*—and the damage is sometimes extensive. Treatment of the seed with formalin—0·5 per cent formalin for five minutes—or copper sulphate affords effective control.

Chemistry and uses.—The Navane grain is cooked and eaten like rice either entire or broken; it is also made into sweet puddings and into porridge. The food value of the grain is given by the following chemical composition:—

Water	Albuminoids	Fats	Carbohydrates	Fibre	Ash
7·5	10·7	4·54	69·2	5·2	3·0 (Leather)
10·2	10·8	2·9	73·4	1·5	1·2 (Church)
11·2	12·3	4·7	60·6	8·0	3·2 (Aykroyd)

VI. WHEAT (Triticum sativum).

VERNACULAR NAMES FOR WHEAT:—*Kannada*-GODHI, *Tamil*-GODUMAI, *Telugu*-GODUMELU, *Malayalam*-KOTAMPAM, *Hindustani*—GEHUN.

Wheat is one of the most important staple food grains of the human race and in certain respects may be said to be of the foremost importance. Wheat is remarkable in the extremely wide distribution it enjoys over the whole globe. It can be grown not only in the tropical and sub-tropical zones but also in the temperate and cold zones of the farthest north, beyond even the 60th N. lat. It can stand intense cold, even that of the northernmost parts of Russia and the polar regions. Sown in the autumn it can stand the cold of the severe winter months and resume growth with the coming in of the warm spring and summer. By the recent technique of 'vernalisation', regions in the far north where it was thought impossible to grow wheat are now being cultivated successfully with wheat. In altitude too, wheat is remarkably adaptable, as it is cultivated from sea-level up to even 10,000 feet.

Wheat has been cultivated in India from time immemorial, as indeed it has been in many other parts of the world. Though the area under wheat in India is very large, totalling some 33 million acres, it is unimportant as far as South India is concerned. More than 95 per cent of the wheat area in India is situated north of a line drawn from Bombay to Calcutta and even in the remaining extent the share of Mysore and Madras is very insignificant.

Soils.—Wheat is grown both as a dry crop and as an irrigated crop. As a dry crop its cultivation is confined almost entirely to the black cotton soils. As an irrigated crop soils of a lighter loamy and alluvial type are preferred, with adequate drainage as for a garden crop.

The soils suited for dryland wheat are the deep fertile, black cotton soils, uniform in texture and free from stones, gravel or coarse sand. All wheat soils generally are more clayey than otherwise. All irrigated wheat on the other hand requires a deep well-drained loamy soil; the extensive wheat tracts of the canal irrigated section in Upper India consist of deep loams of alluvial origin, very uniform and mellow in texture which admits of a profuse development of the root system.

Rotation.—The crop takes only about three months or one hundred days to mature, as cultivated in this country. Wheat is therefore one of two crops taken in the year on the same field, and in garden cultivation even of three. In dry cultivation on the black cotton soils wheat is sown almost invariably as a late season crop about the month of October. Only in exceptional cases it is raised as the early or main season crop. Crops like the different pulses such as blackgram, greengram and cowpeas, and others like gingelly, onions, coriander and short-season groundnuts are raised as the early season crops and wheat follows them in the same year. In many black cotton soil tracts of low rainfall or of rainfall confined to the north-east monsoon, wheat forms the only crop of the year and may be followed in the next year by Bengalgram or coriander and in the third year by a crop of late season jola (white jola) or sajje; these latter are succeeded by one or other of some non-cereal crops before wheat is grown again in the rotation. If the rainfall is suitable, cotton is sown in one year and in the next year is followed by wheat or one or other of the abovementioned crops. In irrigated cultivation, wheat is rotated with a large variety of garden crops including irrigated ragi and even rice; the wheat comes in of course only between two non-cereal crops. In the extensive sugarcane tracts of Upper India, wheat is followed by sugarcane, with either a bare fallow or a green manure crop like sannhemp intervening, or wheat followed by cotton in one year may be rotated with sugarcane in the next year, so that there are three main crops in two years. On the black cotton soils wheat is sown both pure and in mixture with other crops; these comprise either linseed or safflower which alternate with several rows of wheat. When safflower is sown, a good portion of the margins all around the wheat field is sown entirely with safflower, which on account of its spiny character acts as a thorny hedge to keep off stray cattle.

Cultivation.—(*a*) *Dry cultivation.* The black cotton soil is prepared by working the heavy bladed harrow twice after the previous crop is harvested, and then the levelling board or a

light bladed harrow. If wheat should happen to be the only crop of the year the field receives a ploughing in addition before the heavy bladed harrow is worked. After weeds and the roots of the stubble are removed and burnt, the light harrow is worked. The sowing is in the month of October and the field is made ready for sowing by this time. Seed is sown through seed-drills having three tynes about 10 to 12 inches apart, at the rate of about 30 lb. per acre. The seeds sprout in four days and show well above ground in a week. Within the next week or ten days the crop is inter-cultured with the light bladed hoes, which is repeated in the course of a month. In about three months, usually about the middle of January, the crop is ready for harvest. Harvesting is by pulling the plants out by the roots. The crop is brought to the threshing floor and is threshed almost immediately without being stacked for any length of time. Threshing is by trampling under the feet of cattle or under the stone-threshing roller. The produce is screened and winnowed thoroughly before it is stored or sent for sale. The wheat grain is either a clean grain divested entirely of the adhering glumes, or is covered with firmly adhering glumes or husk according to the variety grown. In Mysore considerable wheat of the latter kind—usually called 'spelt'—is grown along with the other varieties. This spelt wheat has to be husked before it can be made use of for consumption, unlike the clean wheat.

(b) *Irrigated cultivation.*—For irrigated cultivation wheat is sown in the months from October to January. The field is prepared in the same way as for dry cultivation, but is well manured. Usually about ten cartloads of cattle manure are applied and ploughed in. Seed is sown either broadcast or in drills in the same way as for dry cultivation. After sowing, the field is laid out into beds suitable for irrigation and a good soaking irrigation is then given. The seed rate is much higher as the crop is sown very thick; about 100 lb. are usually sown per acre. The crop is regularly irrigated once in ten days, usually by flooding; if grown on the black cotton soil (as it is sometimes done) the interval may be increased to 15 days. Weeding is by means of hand hoes and is thoroughly attended to. A small quantity of oilcake (250 lb.) or sulphate of ammonia (about 60 lb.) may be given as a top dressing at the first weeding; the effect is very striking and the growth is very much stimulated. The harvesting and threshing of the crop are as described for dry cultivation. A top dressing with nitrate of soda given when the wheat is about to head out, is claimed to increase the nitrogen content of the grain.

Yield.—When cultivated as a dry crop the yield varies from 500 lb. to about 1,000 lb. per acre, which latter may be considered as a very high yield. In irrigated cultivation the yields are very high and may go up to double the above yields.

Storage of wheat.—On a small scale wheat is stored much

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in the same way as other grains are stored, and the receptacles are grain bags, earthenware bins, wicker bins, and bins with walls of matting plastered over, or formed by hessian. Vast quantities of wheat are however stored in bulk either in large rooms or in underground granaries. These latter are mostly plain excavations in the ground and in these the grain is subject to much damage on account of underground moisture. Substantial underground granaries are also built with sides of stone or brick work, or cement concrete, in all of which the loss on account damp is largely avoided. The concrete granaries are about the best, as they can be kept clean and free from storage pests. In many of the above forms of storage, the grain is much damaged by weevils, mainly the "*Calandra oryzae*" and the "*Trogoderma khapra*" although on a small scale many substances believed to act as repellents are added to the grain heap. In foreign countries and especially in the U. S. A. and Canada, the system prevails of storing wheat in "grain elevators". These structures handle wheat in bulk almost as if it were a fluid, and dispense with the use of bags and of manual labour for carrying them. Divested of many details of construction, these elevators are essentially structures comprising a number of tall circular masonry or metallic bins, which may be small and few in number in the smaller plants but very large and many in the larger establishments. Grain from railroad waggons or farmers' lorries is emptied into a large hopper situated at the base of the structure, from which it is picked up and hoisted to the top of the bins by a series of elevator buckets, much like water in the buckets of a Persian wheel. The grain is delivered at the top into a kind of channel or gutter running between a double row of bins, and in this it is moved or propelled forward by means of an Archimedian screw; as the stream of grain flows along it is turned into one bin after another until the whole series of bins, or such as may be necessary, are filled very much like irrigating one bed after another in a vegetable patch. For taking out the grain, the bins have spouts fitted to them at a suitable level at the base; when they are opened the grain flows from the bin into railroad waggons or into the hold of ships standing by. The elevators are all built of course in situations convenient for this purpose. The only one of its kind in India was erected in Lyallpur in the Punjaub but for various reasons it has not proved a popular institution.

Botany and varieties.—Wheat belongs to the natural order 'Gramineæ' and the genus 'triticum'. Several species are under cultivation which are distinguished from each other mainly by the number of fertile flowers in each spikelet. The inflorescence is a spike and the spikelets which spring from the central rachis comprise one or more flowers; according to the species, one, two or three among these flowers are fertile and set seed while the others do not. Thus, 'Triticum monococcum' has two flowers in each spikelet of which only one is fertile; 'Triticum

polonicum' has four flowers and only two are fertile; 'Triticum sativum' has spikelets in which two or three flowers are fertile.

The bulk of the cultivated wheats of the world belong to the last species, 'Triticum sativum'; in which a large number of races and sub-races and varieties are distinguished. The wheats cultivated in India are 'Triticum vulgare', 'Triticum dicoccum', 'Triticum compactum' and 'Triticum durum'. 'Triticum vulgare' is the wheat which is grown most extensively in India; the grains are white or red in colour, ranging from soft to hard; they are grown both dry and under irrigation. This is the species which is largely used by the milling industry for the manufacture of flour. Both awned and awnless types exist. 'Triticum dicoccum'—also called Emmer and Spelt—has grains in which the glumes are adherent and have to be husked; the grains are hard and flinty and slender. This variety is the one grown under irrigation in Mysore, Madras and Bombay. 'Tritium compactum' is a dwarf wheat with soft rounded small grains and is grown only on a small scale especially in the Punjaub. 'Triticum durum'—also called 'Macoroni' wheat—has grains which are long, pointed, hard and flinty, with a high gluten content. A striking outward feature of many varieties is the presence of long awns, and the varieties may broadly be classed into 'awned' and 'awnless.' Another feature made use of in classifying is 'beardedness', varieties being classified as 'bearded' and 'beardless' wheats.

Wheats in commerce are often distinguished as soft and hard, qualities which depend upon the gluten content of the grains, the soft wheats being more starchy and less glutinous, than the hard wheats. They are also judged by a baking test; the soft wheats give a loaf somewhat dense in structure and smaller in size, and the hard wheats give a loaf a little larger in size and porous or spongy in structure.

In regard to the uses to which wheat is put as an article of food in India, the hard wheat of the 'durum' type and the hard types in the 'T. vulgare' group are found the best for the making of '*chapatis*'. These same types are found most suitable for '*suje*' required for '*halva*' and '*uppumav*' and for the north-Indian preparations '*sewayan*' and '*rabri*'. For purposes where starch forms the important ingredient such as for sizing in textile mills, flour from softer wheats is of course preferred.

Many improved strains of wheat, which have been bred at the Pusa Research Institute, have come into general cultivation and largely replaced the old local varieties. The best among these are the P. 4 and the P. 12. varieties.

Pests and diseases.—Wheat is not subject to any insect pests of importance in South India. The stem borer (*Sesamia inferens W.*) and plant lice may be mentioned but the damage is insignificant. Wheat in storage suffers badly from the pests of stored grain, control measures against which have already been

described. As in the case of other grains and pulses, thorough cleaning and drying of the grains and preservation in fairly air-tight receptacles will keep down the pest. On a large scale fumigation with carbon bisulphide has to be resorted to.

Wheat is however subject to certain diseases which are as widespread and destructive as they are difficult of control. These are the rusts of wheat, black, brown and yellow. The 'yellow rust' is what is most commonly seen in Mysore and whole fields may be seen to be attacked and the crop ruined. The disease is seen in the form of yellow rusty spots on the leaves, especially when the crop is well grown, which extend and eventually dry up the crop. No control measures are known and the breeding of resistant varieties is now receiving great attention in India. Resistant varieties may before long be evolved, although the races of the 'rust' are many and varieties immune to all may be very difficult to evolve. Wheat is also subject to 'smut' and 'bunt' in the same way as other cereals, the affected grains becoming reduced to a mass of black powder. Three different kinds are peculiar to wheat and these are (1) the "flag smut" (*Urocysti tritici*) which is present usually on the leaves and shoots and later in the earheads also, (2) the 'Bunt' (*Tilletia tritici*) which is serious and attacks the earheads, (3) the 'Loose smut' (*Ustilago tritici*) which also attacks the earheads. The treatment for all the three diseases consists in subjecting the seed to spore-killing agencies like hot water, formalin and copper sulphate. The 'flag smut' can be checked by treating the seeds with formalin, the 'bunt' disease by treating the seeds with a two per cent solution of copper sulphate until every seed is bathed in the solution, and the 'loose smut' by immersing the seeds in hot water (129 degrees F.) for a period of ten minutes.

Uses and composition.—The largest and the most important use of wheat is as human food, as bread, both leavened and unleavened, as biscuits, cooked like rice or put up in numerous other forms in different countries. A good deal of wheat bran, chaff and the coarser parts form valuable cattle feeds. Wheat is also used for the preparation of starch required for sizing in textile mills.

The composition of the wheat grain varies to some extent, depending upon the species, type or variety, and upon the soil and climatic conditions. The average composition of Indian wheat is as below:—

Water	Albuminoids	Carbohydrates	Fat	Fibre	Ash	Remarks
12·5	13·5	68·4	1·2	2.7	1·7	Church
12·2	9·9	72·7	1·7	1·7	1·8	Leather
12·9	8·9	72·7	2·1	1·5	2·4	Do
12·8	11·8	71·2	1·5	1·2	1·5	

The gluten (represented by the albuminoids) is subject to great variation, the extremes being 8 per cent in the very soft kinds and 24 per cent in the flinty kinds (Percival).

The different parts of the wheat grain such as the germ, and the different layers of the grain from the outer surface to the interior of the kernel, differ in composition. In modern milling methods, the technique is such that the different portions are largely separated and flour of different composition can be obtained. Thus of nitrogen and of oil these contained proportions as below:—

Portion of the Wheat	Nitrogen per cent	Oil per cent
Whole wheat ...	1·692	2·02
Flour (whites) ...	1·621	1·40
Flour (seconds) ...	1·967	1·82
Bran ...	2·143	2·75
Sharps (fine)	2·608	3·50
	(Church)	

Production and trade.—The total area under wheat in India is 34·4 million acres and the production is estimated at 9·5 million tons. Wheat was being exported at one time in large quantities from India but the export has steadily declined and in 1935-36 was only about 62,000 tons, by both sea and land. Likewise the imports have also greatly fallen and in the same year the quantity imported by land and sea was only about 22,000 tons in round figures.

As already stated, the wheat areas in South India are insignificant. The area in Mysore is only about 2,500 acres and that in Madras is about 18,000 acres.

VII. SAVE (Panicum miliare).

VERNACULAR NAMES FOR SAVE:—*Kannada*-SAVE, *Tamil*-SHAMAI, *Telugu*-SAMALU, *Malayalam*-SHAMA, *Hindustani*-SHAVAN.

'Save' is another dryland grain of minor importance. It is a quick growing crop of three months' duration grown under conditions of low rainfall with moderately good yields of both grain and straw. As in the case of the other dryland grains, its drought-resistant character and its ability to mature a crop however small even in years which may be considered famine years are its special advantages. In Mysore, it is a crop of some importance in the eastern taluks where the rainfall is generally low and conditions of distress are of frequent occurrence. It is really a poor man's crop. The cultivation though not extensive s general throughout India.

It is a crop of the main rainy season and is raised in the months of July to October. The fields are prepared well with frequent ploughings, during May, June and July and got ready as if for a better class of crop like ragi. In fact, ragi, is sown if timely rains are received , but as this is not generally the case, 'save' is sown instead. The seed is sown in drills and covered with the bladed harrow, or is sown broadcast and covered with the plough or a toothed harrow, the seed rate being about 8 to 10 lb., per acre. A mixed crop of horsegram or 'togare' may also be sown though this is not usual, the crop being sown pure and followed in the next year with horsegram. Little or no after-cultivation is given and the crop matures in three to four months, depending upon the variety sown. The variety called 'kari' ripens in four months, the variety called 'bili' ripens in 3½ months and the one called 'malige' ripens in three months. The crop is harvested by pulling out the plants whole with the help of sickles in addition. The sheaves are stacked for a week and the grain is threshed out by trampling under the feet of oxen. The straw is very thin and soft and is readily eaten by cattle. In olden days it is said to have been much used for stuffing pack saddles, on account of its softness.

The yield of grain amounts to some 300 to 500 lbs. per acre on the average while in good seasons it may go up to 800 lbs. Like the other millets, the 'save' is an annual grass ; it has thin leafy stems, tillers profusely, and attains a height of two to four feet depending upon the variety. The panicles are about a foot in length, with drooping filiform branches. Out of the four glumes, the first two are empty, the third contains a neutral flower and only the fourth is bisexual and bears seeds. The grains are either white or greenish white in colour.

The food value of the grain is given by the following chemical composition :—

Water	Albuminoids	Fats	Carbohydrates	Fibre	Ash
10·2	9·1	3·6	69	4·6 3·5	(Church)
7·9	6·9	4·1	67	7·6 6·2	(Leather)

VIII. HARAKA (Paspalum scrobiculatum).

VERNACULAR NAMES FOR HARAKA :—*Kannada*-HARAKA, *Tamil*-VARAGU, *Telugu*-ARIKELU, *Hindustani*-KODRA.

'Haraka' is easily the coarsest among the food grains and also remarkably drought resistant. It is relegated to rough gravelly and stony soils, light upland soils and all poor soils generally, or the red, ashy grey and light red types. In spite of adverse conditions the crop can struggle on even on these soils and yield a

small crop of coarse grain and a straw low both in quality and in quantity. The crop occupies the ground for six months, a period longer than that of any other dryland grain.

It is a crop of minor importance and only small areas are cultivated. Only one crop is raised in the year and it is followed in the next year with horsegram or castor. The field intended for 'haraka' is ploughed several times in the months of May to July after heavy rains are received and is prepared well as for the better class of grains. The grain is sown broadcast after a good sowing rain about the end of July. It is also sown in rows either in drills or in plough furrows. The seed rate is about 20 lbs. per acre. When the crop is about six inches high the field is worked with the toothed interculturing hoes once along the length of the field and once across. Sometimes a hand weeding is also given. In Mysore, the crop is grown under comparative neglect, attention being given to it only after the needs of the other crops are fully met. The long season over which the crop grows favours many kinds of weeds which grow unchecked and even ripen and set seed. In six months the crop is ready for harvest; it is cut close to the ground and brought over to the threshing floor, where after lying in the stack for about a week it is threshed by trampling under the feet of oxen. The crop attains a height of two feet and tillers only moderately with the result that the straw is quite inconsiderable. It is poor fodder and is not much eaten by cattle. It generally goes into the manure heap. In Madras, it is said to be applied as manure for alkaline soils. The grains which somewhat resemble the grains of buckwheat have a hard horny coat, which has to be broken and removed before the edible part inside can be obtained and used. The outturn of flour in the grain is low and the process of removing the husk itself is troublesome. The grain usually contains considerable admixture of weed seeds, from which it has to be cleaned thoroughly. It is generally eaten by only the very poor among the agricultural classes.

The yield of grain in Mysore varies greatly from 200 lbs. to 500 lbs. per acre. The crop is sometimes grown with some care like other crops and then a mixed crop of 'togare' is sown with it and even manure applied. Yields in such cases may go up to 600 lbs. and even 800 lbs. per acre.

Botany and varieties.—'Haraka' belongs to the genus Paspalum and is quite distinct from the other cereals. It is a smooth annual grass growing somewhat erect, attaining a height of 18 inches to 2 feet and tillering to a moderate extent. The leaves are stiff and thick, adding to the erect appearance of the plants. Both stems and leaves are suffused deep red in colour especially when conditions are very dry. The leaves are very narrow and extend beyond the length of the inflorescence. The inflorescence is a thin long raceme with the spikelets arranged on one side of a flattened rachis. The spikelets are one-flowered. There do not appear to be any distinct varieties under cultivation.

Pests and diseases.—Haraka is very hardy and singularly free from pests and diseases. A common trouble however is with the white ants which follow in the wake of the very dry conditions and the comparative neglect to which the crop is subject. Many plants often succumb, leaving gaps here and there.

Among diseases, a rust disease and a smut are reported, but both are rare and insignificant.

Chemistry and uses.—The grain is recommended as a substitute for rice to patients suffering from diabetes in the same way that ragi and wheat are recommended. Both grain and straw are said to develop a poisonous principle under certain circumstances which renders them unfit for consumption. It is also believed that the grains under certain conditions may cause vertigo. The chemical composition of the grain showing its food value is as below .—

Water	Albuminoids	Fats	Carbohydrates	Fibre Ash	Remarks
Whole grain	8·0 5·8	3·3	70·0	8·4 4.2	(Leather)
,,	12·8 8·3	1·4	65·6	·9 2·9	(Aykroyd)
Husked grain	11·7 7·0	2·1	77·2	·7 1·3	(Church))

IX. BARAGU (Panicum Miliaceum)

VERNACULAR NAMES FOR BARAGU :—*Kannada*—BARAGU ; *Tamil*—PANIVARAGU, KADAIKANNI ; *Telugu*—VARIGALU ; *Hindustani*—BARRI.

Another minor crop of some importance is 'Baragu', Panicum miliaceum, which is closely similar to the crop 'Save' (Panicum miliare). It is a quick growing grain crop, which is highly drought resistant, and is esteemed accordingly for growing as an emergency crop, when the season is past for the sowing of the main season food crops like ragi and jola or in situations which could not be got ready for sowing in the main season. In Mysore, it is almost exclusively a dryland grain, though elsewhere as in Madras it is usual to grow it as an irrigated crop also. As one of the millets of the world, it is one of the oldest grain crops and is grown extensively over many parts of the world, besides occurring as part of the natural vegetation. Claimed variously to be a native of Central Asia and of Egypt and Arabia, the grain has a wide range of cultivation, which extends from Japan through China and Central Asia to Southern Russia, Central and Southern Europe, throughout Africa and the larger part of the American Continent.

Like the other inferior millet 'Save,' it is grown generally on the poorer types of soils, the better soils being devoted to

major grains. It is grown mostly on the red loamy soils and the grey light loams and sandy soils. The heavier types, the dark rich soils and the black cotton soils are not put under this crop. It is raised as a 'hingar' or late monsoon crop and is often the only crop of the year, chiefly because no crop could be sown in the early or in the main season on account of lack of rainfall. The land is generally in a well-prepared condition, when the crop is grown on land intended for ragi or jola but more often the preparation is very little as the crop is sown in a hurry and the land could be ploughed only once or twice. The crop however responds to good cultivation; and if conditions would permit, then the soil will have to be ploughed well, clods broken, stubble and weeds removed, the surface harrowed and a good tilth obtained. These operations should in any case be complete before the beginning of October when the crop has to be sown.

Seed is sown through seed drills in rows nine inches apart and covered with a brush harrow. Seed is sown at the rate of about 8 to 10 lb. per acre. Broadcasting at the same seed rate is also adopted when on account of a poor season, both preparatory cultivation and sowing have to be hurried through. The crop is later on intercultured and also hand-weeded once. In three months the crop is ready for harvest. The plants are pulled up by the roots and are brought to the threshing floor. As the crop sheds badly it is not stacked but is threshed soon after harvest, the grain being either beaten out or threshed under the feet of oxen. The straw is inconsiderable but it is a good fodder. The yield is varying and generally precarious but in well grown crops it may amount to 400 to 500 lb. of grain per acre. Under irrigation the yield may go up to double this quantity.

Botany and Varieties.—Baragu-*Panicum miliaceum*—belongs to the order Gramineæ, and is an erect herbaceous annual, which tillers freely and grows rather low, reaching a height of 18 inches to two feet. The roots are fibrous and very shallow. The leaves are linear and slender and the leaf sheaths enclose the entire internodes. The inflorescence is a panicle, slender and much branched, with the spikelets at the tips of the branches, generally in ones and twos. The last or fourth glume encloses a perfect flower which sets grain. The glume and pale are firmly attached to the grain. There are several varieties which differ mainly in the colour of the grains; these are grey, yellow, olive grey, and ivory yellow according to variety.

Pests and diseases.—The crop is not subject to any insect pests of importance nor to any fungous diseases. A smut disease in which the whole earhead is affected is seen to attack the crop but it can be controlled by treating the seed with copper sulphate as in the case of the jola smuts. A kind of rust is also seen but neither disease is of any importance.

Chemistry and uses.—'Baragu' is one of the coarse millets; the grains are eaten cooked like rice or ground into flour and eaten as porridge or pudding. The chemical composition of the grain is as below :—

Moisture—11·9 ; Albuminoids—12·5 ; Fats—1·1 ; Carbohydrates—68·9 ; Crude fibre—2·2 ; Ash—3·4 (Aykroyd).

X. BARLEY (Hordeum sativum).

VERNACULAR NAMES FOR BARLEY :—*Kannada*-JAVE GODHI ; *Hindustani*—JAU.

Barley is a grain crop which resembles wheat in many respects. It is a crop of very ancient origin and for a long time was of equal importance with wheat as a food crop. At the present time, however, barley is grown principally for conversion into malt for brewing into beer and for distilling into spirituous liquors. Like wheat, barley is largely grown only in the temperate and cold zones of climate, and is of very minor importance in tropical countries. The cultivation extends even further north than that of wheat and is said to reach as far north as the 67th and 68th latitude North, round the shores of the White Sea in Northern Russia. It is also more adaptable and has a wider range of cultivation than wheat. In India, its cultivation may be said to be of very minor importance; it is grown in parts of the United Provinces, the Punjaub and the North West Frontier Provinces and to a small extent in Bombay and Bengal. In South India, it is quite insignificant and may be said to be almost non-existent.

Barley is grown on deep fertile soils, more of the loamy type than clayey, in contrast with wheat which flourishes on somewhat clayey soils. Barley also requires a well prepared soil in good tilth and thoroughly free from weeds. In fact, in the famous "Four course rotation" of Norfolk, *viz.*, Roots, Barley, Clover, Wheat—it will be seen that barley follows the root crops which are the cleaning crops in the rotation, unlike wheat which comes last, following a succession of crops which leave the land weedy and greatly in need of cleaning.

In India, it is cultivated in the late season, *i.e.*, in the months October-November, at the close of the North-East monsoon very much like wheat. It is grown almost as a garden crop with moderate irrigation; or as a dry crop on retentive soils. It is grown either pure, or in mixture with a variety of crops, principally some leguminous crops like peas, Bengalgram or lentils. Very often it is grown in mixture with wheat itself, or with mustard or linseed.

Cultivation.—The field for barley has to be ploughed several times, clods broken and all weeds and stubble removed and burnt.

In garden cultivation, the field is heavily manured with cattle manure at the rate of ten cart-loads per acre which is well worked in. The field is also harrowed and rolled to obtain a fine tilth and a firm seed-bed. Seed is sown either broadcast or more often in rows. In the latter case, it is sown generally in shallow plough furrows drawn about nine inches apart, the seed being dropped through a one-furrow drill. Seed has to be sown very thick, and from 80 lbs. to 100 lbs. of seed are required for an acre. The field is lightly harrowed to cover the seed, and is left level for forming irrigation beds in the case of garden cultivation. Where a mixed crop is sown, the barley and gram or lentil are sown in alternate strips of more or less the same width and containing the same number of rows. In the case of the irrigated crop, the field is irrigated once a week or ten days. The field is kept clean of weeds, and at least one interculture is given with a bullock hoe in addition to hand-weeding. The crop responds like wheat strikingly to nitrogenous manuring and a top dressing with a small dose of ammonium sulphate at the rate of one cwt. per acre may be applied which may be supplemented with advantage with one and a half cwts. of superphosphate. The barley becomes ready for harvest in four months. Harvesting consists in pulling out the plants with the roots or in cutting them down with sickles. The sheaves are brought to the threshing floor and stacked, and the grain is threshed out after a week or ten days. The sheaves may also be allowed to remain in the stack for a much longer period and the threshing taken up thereafter. The grain is threshed out either by beating out with sticks or by trampling under the feet of oxen.

Yield.—The yield of barley under irrigated cultivation is estimated at 1,500 lbs. to 1,800 lbs. of the grain and about a ton of straw per acre. Grown without irrigation and as a mixed crop, the yield of grain per acre may amount to 800 lbs. or 900 lbs.

The average yield in the colder countries as in England goes up to 1,800 lbs., while good yields approach 3,000 or even 3,500 lbs.

The straw is rough, brittle and not good as fodder.

Botany and Varieties.—Barley—*Hordeum sativum*—belongs to the natural order Gramineæ and is an annual tufted grass growing to a height of about two to three feet. The root system is profuse and fibrous and 'woolly'. The leaves are linear lanceolate with a white midrib and the leaf blade is about 9″ to 12″ in length and ½″ to 5/8″ in breadth. The ligule is prominent and membranous and the leaf base is auricled. The inflorescence is a simple cylindrical spike and consists of many groups of three single-flowered spikelets arranged from top to bottom on an elongated rachis. The flowering glume in each flower bears a long awn. The fruit (barley grain) is adherent to the

glume and pale and does not thresh free from these tissues (except in the so-called 'naked barley').

The cultivated varieties are grouped into three races, *viz.*, (1) the six-rowed, (2) the four-rowed and (3) the two-rowed. The barley commonly grown in India is the six-rowed type. There are many sub-races and varieties distinguished which differ in their height, stiffness of straw, length of spike, yield of grain and 'malting quality' of the grain. A famous malting barley is 'Chevalier' (a two-rowed barley) which excels all others in this quality, though the plants are said to be delicate and liable to lodge.

Many selections have been made and isolated among the Indian Barleys, and are being tested for their malting qualities with a view to evolving superior malting types.

Pests and diseases.—Though barley is subject to the diseases that are commonly found on cereals, the attack of none of these is serious, as in the case of many others. For this reason barley is sometimes preferred to wheat as a food grain by cultivators. In common with the other cereals, barley is subject to mildew, smuts and rusts; the remedies are the same as those already described under other crops. The attacks, however, are far from serious in the case of barley.

Malting quality.—Barley is judged for quality by its suitability for malting purposes; the better this feature of the grain, the more highly priced it is. The malting quality depends really upon the chemical composition of the grain, but external characters also form a fair index. A good malting barley contains a high percentage of starch and a comparatively moderate or low percentage of proteids. The starch should run as high as 62 to 64 per cent while the proteid content in the best samples should not go higher than 9 or 10 per cent. In medium samples the proteids go up to 11 per cent while poor ones exceed 12 per cent. A good malting barley gives a rich water extract which is at the same time light coloured and clear and not turbid. The outward characters which indicate good quality are plumpiness and weight, a pale yellow or straw colour uniform and not blotchy over the grain, a white mealiness (as distinguished from flintiness) of internal structure, freedom from mouldiness and a high percentage of quick and uniform germination. Many of these factors are influenced by the variety, soil, time and method of harvesting and threshing and the after-care of the grain.

Chemistry and uses.—The barley grain is made use of very largely for the manufacture of beer and of the highly spirituous liquors, like whisky, brandy, etc. As a food, barley flour is prepared into unleavened bread; it is also broken and roughly ground into "pearl" barley. As already stated the barley grain has the glumes firmly attached to it and from these it cannot be freed by threshing. The grain has to be broken and then the

glumes winnowed off. The glumes are easy of removal if the grain is fried. In addition to human food, barley is largely used for feeding to cattle and pigs.

In chemical composition, the following may be taken to represent average samples:—

Moisture 12·5, Albuminoids 11·5, Carbohydrates 74·0, Fats 1·3, Crude fibre 3·9, and Ash 1·5 (Aykroyd). The grain is however subject to great variations in composition. The carbohydrates may, for instance, go down to 62 per cent, while the proteids may go upto 17 per cent and also be as low as 6½ per cent (Percival).

XI. MAIZE (Zea mays).

VERNACULAR NAMES FOR MAIZE:—*Kannada*-MUSKIN JOLA; *Tamil*-MUKKA CHOLAM; *Telugu*-MOKKA JONNALU *Malayalam*-MAKKA CHOLAM; *Hindustani*-BUTTA.

Maize, also called Indian Corn, (or merely "corn" in the U. S. A.) is a food grain of considerable importance in many parts of the world, notably in North, Central and South America. To an even greater extent the grain is used as food for all kinds of farm animals, while the plants themselves furnish large quantities of succulent green fodder and are grown almost as much for their value as green fodder and silage as for the grain. The grains find considerable industrial use in many ways unlike other food grains, and the dry stalks and other parts of the plant likewise find similar uses. The crop is said to be a native of Central America and Mexico from where it has spread to other parts of the world. Even in India although there are varieties which may be regarded as local, as distinguished from the large number of American varieties which have displaced them, the crop is regarded as only a foreign introduction. The crop has a very wide range of cultivation and is grown throughout the tropical zone; varieties have also been evolved which suit the colder zones, and the crop can be grown in all such regions where the summer is long enough to permit its cultivation, and frost does not set in too early. In America the crop is grown from the equator to the borders of Canada, and the 40th latitude North may be put down as the limit of cultivation. In India, maize is a food crop of some importance, though it is only in Bengal and the United Provinces that it is grown on a field scale; elsewhere to a large extent it is grown on small areas almost like a garden crop, though in the aggregate, the extent is not inconsiderable. The produce may however be said to be almost entirely made use of for human consumption.

Soils.—Rich soils well-drained and generally light or loamy in character and more or less of the type selected for garden crops are those which are best suited for the maize crop in preference to heavy soils of the clayey or clayey loam type. The easy working deep alluvial loams and the red loams which are deep and free from coarse materials are very suitable soils. In Bengal, however, coarse gritty soils on hill sides are also said to yield good crops of maize. The crop requires heavy manuring even on soils which may be considered naturally fertile. The heavier dark coloured type of loams and black cotton soils which are naturally rich can be put under maize provided their physical condition is improved by the addition of sand. As a matter of fact this is a common practice adopted in the case of many garden crops and applies equally well to the maize crop.

Rotation.—There are short duration and long duration varieties in maize; it can therefore form either the single crop of the year or one of two or even three crops grown in the same year. Maize is grown both as an irrigated crop as well as a purely rain-fed crop. The former is of course invariably the case in garden cultivation; while in the case of the crop grown on a field scale, it may be rain-fed or irrigated. It is, however, only in tracts of moderately high rainfall exceeding 30″ that the crop can be grown as a rain-fed crop. The crop can be grown both in the early rains and in the later rains, and practically any time of the year in garden cultivation. Moreover, maize is grown either by itself or more often with a subordinate mixed crop, generally of the low growing type which will occupy the ground between the rows of the tall-growing maize crop. In garden cultivation, it is the short duration variety which is grown, and is followed by one or other of a variety of crops such as French beans, potatoes, chillies, onions or chrysanthemums and sometimes even by irrigated ragi though this is also a cereal crop. When grown on a field scale, it is either the only crop of the year or one of two crops. In the former case (as in Bengal), wheat or barley follows it. In the latter case, Bengalgram, mustard or safflower follows it in the late season. Where it is planted in the late season, carrots are sown in between the rows as a subordinate crop (U. P.).

Cultivation.—Maize requires a well-tilled and highly fertilised soil. The preparation of the soil is carried out in time to suit the sowing season, which is April-May for the early crop, June-July for the mid season and September-October for the late season crop. The field is dug deep with hand tools (in small scale cultivation) or is ploughed several times; clods are broken, weeds and stubble removed and burnt and the ground well harrowed and levelled. Cattle manure at the rate of ten to fifteen cart-loads per acre are applied and ploughed in and the field harrowed again. In garden cultivation, the plot is laid out into beds suitable for irrigation and shallow furrows drawn at distance of 12″ apart for sowing the seeds. If a subordinate crop is to be

sown between the rows, then the latter are made wider, from about two feet to three feet apart or more as may be desired. In field cultivation, the furrows for sowing are made 18″ apart. Seed is generally sown by dibbling by hand at a distance of about 10″ from each other in garden cultivation or 18″ apart in field cultivation. With the soil sufficiently moist with irrigation or rain, the seeds sprout in about six days and in two or three days more the braids are seen well above ground. Growth is slow at first but from about the third week the crop grows with remarkable rapidity. Weeding, earthing up of the rows and irrigation are attended to in the ordinary way. In two months, young cobs fit for eating raw or boiled are ready and in three months or 100 days the cobs are ready to pick quite mature. The late varieties take from four to even six months and these are usually allowed to become dead ripe and the plants and leaves to dry in the field. More usually, however, the short duration variety is sown and the plants are cut down immediately after the cobs are picked, when the stems and leaves continue to remain green and succulent. Very large quantities of green fodder thus become available.

Yield.—Maize cobs are generally gathered for being sold partly as green cobs, somewhat past the dough stage and partly as ripe cobs for being eaten toasted. Where the cultivation is on a very large scale, the cobs are gathered dead ripe to be hulled and stored or sold like any other grain. Ordinarily only one cob can be reckoned on each plant, but on rich soils many plants may carry two cobs each and 100 plants on the average may carry 150 cobs. The ordinary yield of shelled maize may amount to 600 or 700 lbs. per acre, but good yields may amount to 1,200 to 1,500 lbs. In the U. S. A. the average yields range from 10 bushels (1 bushel=60 lbs.) in the poor corn States, up to 36 bushels in the best corn States. Yields for the best individual fields may go to 60 bushels or 3,600 lbs. per acre. In small scale garden cultivation where green cobs are harvested and sold, an acre may produce between 20,000 and 30,000 cobs.

Botany and Varieties.—Maize—*Zea mays*—belongs to the natural order Gramineæ and is an annual tall growing grass considered to be a native of Mexico. It is met with only in its cultivated form and no wild species is said to exist; although the grass "teosinte" is the nearest approach to it in natural vegetation. The root system is fibrous and deep; adventitious aerial roots spring from the lower nodes of the stem and act both as anchoring or 'bracing' roots and as feeding roots. The stem is thick, rounded and very tall varying from four to ten feet according to variety. The plants do not tiller except in rare instances such as in some dwarf varieties. The nodes are thick, part of the internode is grooved, and the internodes are solid unlike in most grasses. The leaf blades are long, broadly linear. The flowers are borne on two different parts of the plant; the

male flowers are borne in a cluster (called a 'tassel') on the top end of the stem as a terminal panicle, while the female flowers are borne inside the young cob which springs from one of the nodes on the stem. The male spikelets are two-flowered and the stamens are three in number. The female spikelets are one-flowered, sessile and densely packed in several vertical series on the thick and cylindrical rachis. The style is a very long silky filament (the cluster of which is referred to as "silk") and the ovary is obliquely ovoid and plano-convex. The grains are rounded, flattish and disc-like, and are of varying colours such as yellow, red, orange, purple and creamy white. There are a very large number of varieties in cultivation which differ not only in characters like height of growth, duration of crop and colour and shape of seed but also in the character and composition of the seed and its suitability for various purposes. The following varieties are distinguished in the U. S. A.: (1) Dent corn, (2) Flint corn, (3) Pop corn, (4) Soft corn, (5) Sweet corn—all of which differ mainly in the respective proportion and character of the different parts in the interior of the seed. A curiosity is the "Pod Corn" in which each seed is enclosed in a miniature pod or husk and the whole cob also similarly enclosed. In recent years a cross-bred type called "Hybrid corn" has been evolved which is resistant to the borer insect and is a heavy yielder and which is now largely in cultivation. A great intensification of the difference in the character of the seed such as starchiness, oiliness, proteid content and so on has been secured as the result of breeding by "selection."

Pests and diseases.—The maize plant is subject to many of the insect pests that attack ragi, jola, and other grain crops such as grasshoppers, hairy caterpillars, shoot borers, etc. The remedies are the same as have been already described. The crop suffers in addition by insect attacks on the cobs. These are larvæ of a large greyish brown moth—*Heliothis obsoleta*—and are the same as the cotton boll-worm. They feed on the tip end of the cobs and destroy the grains at this end. They also destroy the leafy tissues near the cobs and open the way to weevil attacks on the ripe grains. The remedy is only of a preventive character and consists in ploughing up the field after the harvest, thereby destroying the pupæ resting in the soil and stubble. The grain is attacked both in the field on the cob itself and later in storage by the weevils attacking stored grain. The attack in the field is almost impossible to combat and the remedy lies only in growing resistant varieties. In storage, the large scale method of fumigation by carbon-disulphide is the only effective remedy. In a small way and for seed purposes cobs can be preserved as such, tied to the ceiling in the kitchen where smoke and heat keep them free from weevil attack.

Maize is subject to the attack of a corn smut (*Ustilago maydis*) in which the contents of the grains consist of the black spores of the disease and the grains are rendered useless. The disease is not seed-borne and is not amenable to any seed treatment. Burning of the crop debris and a suitable rotation are the methods of prevention which are of some practical value.

Chemistry and uses.—The maize crop is utilised in very many ways somewhat in contrast with the other grain crops. It is firstly a food grain of considerable importance, being eaten as such and more largely ground into flour. The grains form an important cattle food, being fed to farm cattle, horses, and pigs. The different parts of the plant and the grain are put to a number of industrial uses and various articles are manufactured from them. Thus the "silks are used as a filter, husks for the making of mattresses, the pith of the stalks for the packing of coffer-dams of battle-ships, the outer parts of the stalks for the making of pyroxylin varnishes and paper, cobs for the making of corn pipes." The papery covers of the cobs are used as wrappers of the "clove cigarettes" of Malaya, and for "tamale", a Mexican dish. The stalks and cobs are made use of for the preparation of furfural. The grain itself furnishes (1) Corn oil, which is extracted from the germs; the oil is used as a cooking oil and also for being vulcanised and used as a substitute for natural rubber and (2) from the starch, products like (*a*) glucose, (*b*) dextrin and (*c*) American gum, (*d*) starches for edible purposes and laundry. The special variety called the "Pop, corn", the grains of which are characterised by a hard corneous interior structure, are converted into the "popped" form which is a favourite food in all maize-growing countries.

The maize crop furnishes also huge quantities of green fodder which is used mostly in the form of silage. The crop lends itself admirably to ensiling both by itself and, as is more often the case, in combination with a leguminous green crop like lucerne (alfalfa) or cowpeas.

The chemical composition of average samples of maize grain is as shown below:—

Water	Albuminoids	Fats	Carbohydrates	Crude fibre	Ash
10·5	10·4	5·0	70·2	2·0	1·4

SECTION II

PULSES

I. TOGARE (Cajanus Indicus).

VERNACULAR NAMES FOR TOGARE :—*Kannada*-TOGARE ; *Tamil*-TOVARAI ; *Telugu*-KANDALU ; *Malayalam*-TUVERA ; *Hindustani*-TUR.

'Togare' is an important crop which furnishes an indispensable part of the daily dietary in South Indian homes. As a cultivated crop, it is said to have existed in India from very ancient times although it is claimed that the home of the plant is outside India. It is grown extensively throughout India while in South India it is the pulse crop that is most in daily use, supplementing as it does by virtue of its being a rich proteid food the highly starchy diet of the people of this part of India. In Upper India, its importance is shared by the other pulses like Bengalgram and lentils. It is grown almost invariably as a mixed crop with the dryland cereals ragi, jola and 'sajje' and the conditions of soil, climate, the season for sowing and the method of preparation of soil already described as suited to these crops apply to the 'togare' crop as well. In South India, it is grown almost entirely as a dry crop although one variety is to some extent grown as an irrigated garden crop also. In Upper India, however, over considerable areas the crop is irrigated.

Cultivation.—The crop is grown as a mixture in ragi, jola or 'sajje' in rows about six feet apart, the space between two rows being occupied by the cereal crop. The seeds are dropped into plough furrows either by hand or through a one-furrow seed-drill —the 'sadde'—and covered by one or other types of harrows or merely with the feet as the sowing goes on. Sown in this way, about 4 lbs. of seed is used for an acre. The sowing takes place in the months of May to July, the early sowing in the case of the Kar ragi or early season jola and the later sowing with the main season ragi or jola. In ten days the plants show above ground. The crop shares in the hand-weeding, inter-culture and other operations carried out for the cereal crop. The 'togare' plants are considerably thinned out in this way, so that they stand about 12 to 18 inches apart in the rows. The plants make very slow growth until the cereal crops are harvested and removed. The ground between the rows of 'togare' is now ploughed or worked with the bladed harrow and the growth thereafter is quick and vigorous. With good seasonal conditions

the plants attain a height of some five or six feet, with numerous side branches and covers the ground almost completely. The stem becomes thick, woody and strong, attaining a girth of about four or five inches at the base near the ground, where the plants have been thinned to about two feet from each other in the rows. Otherwise, the plants do not attain this sturdy growth. Flowering goes on continuously over two months and flowers, green unripe fruits and ripe pods are all to be seen at the same time. A good deal of picking of the ripe pods has to be carried out before the plants can be cut down, so as to prevent the pods from splitting and scattering the seeds. The crop is harvested in from six to eight months, *i.e.*, from December to March. Much of the leaves are shed by this time and form a mat on the ground adding no doubt to the fertility of the soil. The plants are cut level with the ground and loaded into carts provided with cribs in order to save the seed dropping from the ripe pods which split to a large extent. In the threshing floor the bundles of the plants are arranged in an erect position with the branches pointing upwards and are then beaten with long sticks to thresh out the pulse.

To a small extent, togare is grown as a pure crop also in South India, and in North India over immense areas. The seeds are, in these cases, sown in rows about three feet apart and in the rows themselves either two feet from each other or three feet.

The variety called 'garden togare' is a large bush and occupies the ground for more than a year almost like a perennial. It is grown on the margins of sugarcane fields almost like a thick hedge. It is also grown in gardens along with turmeric, sweet potatoes and various vegetable crops, all of which latter are grown as ground or low growing crops between the rows of the ' togare ' which grows high and bushy enough to be regarded as a shade crop, for the turmeric. The togare is sown in rows about six feet apart and almost the same distance in the rows. The pods are picked green when the seeds are three-quarters ripe and the seeds are removed and eaten like green peas. Both the fruits and the seeds are much larger than in the dry land variety or field ' togare.'

Yield.—Yields from the field crop are generally high and will range from 400 to 600 lbs. per acre when grown as a mixed crop. If grown pure, yields may go up to between 800 and 1,000 lbs. per acre A Mysore seer of ' togare ' weighs 2·1 lb.

The husks or parts of the dry pods after the seeds are threshed out are considered valuable as a cattle feed and are therefore carefully preserved, usually, inside the straw stacks. The dry stems are used for various purposes such as a thatch for the large jola straw stacks, for lining the sides of carts and generally much like wattle or wicker for different purposes. They are also used as fuel and the ash is said to be bought up by makers of gunpowder.

Botany and varieties.—The 'togare' plant belongs to the order Leguminoseæ and is classed as a sub-tribe 'Cajaneæ' under 'Phaseoleæ,' one of the divisions of the 'Papilionaceæ.' It is a perennial woody shrub grown, however, as an annual. The stems are strong, woody and rounded, slightly ridged, freely branching and reaching a height up to eight feet. The root system is deep and extensive and covered with nodules. The leaves are pinnately trifoliate, the leaflets being oblong lanceolate and detted with numerous minute glands on the lower surface. The infloreṡcence is a raceme, terminal or springing from the axils, in the upper branches of the bush. The calyx is campanulate and toothed, the corolla standard yellow, or veined with black and blotched yellow, the wings obliquely obovate and clawed; the keel has an incurved lip, the stamens are diadelphous, the ovary sub-sessile, and the style long and beardless. The pods are two to four inches long according to variety, about a quarter inch in breadth, densely glandular, pilose and dark green with purple streaks. The seeds are 2 to 5 in number and are separated from each other by slight depressions on the outside of the pods.

Two varieties are distinguished, *viz.*, Cajanus indicus var. flava, and C. indicus var. bicolour. The latter has the corolla standard somewhat yellow blotched and veined purple, with the wings also likewise tinged purple. The pods are longer and wider than in the former variety. The seeds are also more in number, between four and five as against two and three in the former. In the field 'togare' itself, *viz.*, the 'flava,' two types are known, one of which is an early maturing type and the other a late maturing one.

Pests and isdeases.—'Togare' plants in the young stage are subject to the attacks of the jola grasshopper and the hairy caterpillar, along with the ragi or jola crops with which they are grown as a mixed crop. The control measures have already been described under ragi and jola. When the pods are formed, they are attacked by pod-boring larvæ of several kinds which eat into the young seed and do considerable damage. These are (1) the *Heliothis obsoleta,* (2) *Exelastis atomosa* or the plume moth and (3) maggots of the fly, *Agromyza obtusa.* For none of these pests is any satisfactory remedy applicable on a field scale known. The plants are also subject to many other pests, leaf eating, stem and pod-boring and sap-sucking, the damage from which, however, is seldom serious.

'Togare' is subject to the pests of stored pulses and grains in the same way and to the same extent. The damage caused is always serious and unless great precautions are taken, a large percentage of stored 'togare' will be found-showing the holes characteristic of the attacks. Seed 'togare' is preserved in basket-like receptacles made of straw twist, and often mixed with ashes, chilly powder and so on, in the belief that these act as repellents. A better method will be to dry the seeds in the sun thoroughly,

clean them and then preserve them in earthenware or metal receptacles, covering the top with a two-inch layer of sand.

Wilt disease.—The most serious disease of togare is the wilt disease. Plants are attacked both in the young stage and when grown up; it is, however, the latter that is conspicious and attracts notice. Large well-grown plants are often seen to succumb completely and dry up on account of the disease. Fields may be met with in which the diseased plants are in patches here and there all over the field, the healthy areas being occupied by the part of the crop which is evidently resistant. The wilt of the 'togare' is different from the wilt of the cotton plant. The 'togare' wilt is due to the attack by a soil-dwelling fungus—*Fusarium udum, Butl.*—which gains entry into the plant through the root and which can live in the soil for long periods even in the absence of the host plant. Infection also takes place by means of wind-borne spores, from attacked plants even from a considerable distance in the field, though such infection can obviously begin only when the crop is well grown and late in the season. The remedy seems to lie only in the growing of resistant types; many such have been isolated in the different provinces, which are claimed to be very materially immune.

Dhall or Split Pulse.—'Togare' is converted into 'dhall' or split pulse with the husks removed before it is sold for consumption. For this purpose the seeds are put into water and kept fully submerged for some six to eight hours, until the outer skin just begins to show wrinkles. They are then taken out, smeared over with a paste of red earth and kept heaped up for eight to ten hours. The husks of the seeds become somewhat softened in the process and also slightly loosened from the fleshy cotyledons which form the dhall. The seeds are then spread out in the sun to dry and are taken for husking soon after or are sometimes mixed with the moist red earth a second time, heaped up over night and then put out to dry in the sun. When quite dry, they are put through a sieve and also winnowed in order to remove the adhering earth; the husking itself follows thereafter and is conducted either with a mortar and pestle or with the domestic husking or grinding mill, which husks but does not break the 'dhall'. In this process the husks are removed and the seeds split into the two cotyledons. The mixture of the 'dhall' broken bits and husks is then winnowed and sifted. Dhall can also be prepared by what is known as the "dry process". For this purpose the pulse is smeared over with gingilly or coconut oil, dried, and then put through the husking mill; a portion becomes split and de-husked. This is now separated and the remainder is again treated with oil, dried and put through the mill. A further portion is split and de-husked and after separating this out, the process is repeated with what remains. The splitting and husking take place thus in fractions, and three or four repetitions are required to complete the process. The

'dhall' is sold for human consumption and the husks and broken bits for cattle feed, for which purpose it is greatly esteemed and is in great demand, especially for animals in milk.

Boiling quality —The boiling quality of 'togare dhall' is an important character which decides the price of the article. Those grades which boil or soften quickly with a large portion of the constituents diffusing into the water in which it is boiled are considered the best, and those which are poor in this respect and are inordinately slow in softening and diffusing rank much lower. Varieties in which the 'dhall' is thick, small and almost rounded are preferred to those in which the dhall is thin and flattish and somewhat larger in diameter than the first. They are appropriately referred to as 'leaf-dhall'. Poor qualities also contain considerable admixture of greenish 'dhall' which is due to the seeds being not quite mature. Both variety and soil probably influence the boiling quality and it is sometimes believed that the presence of considerable lime in the soil as in the case of the black cotton soils improves the boiling quality. The water used for soaking and for mixing with the red earth paste is also credited with special properties but the matter is not at all properly cleared up, in spite of its important bearing upon the quality of this widely used pulse.

Chemical composition.—'Togare dhall' is an important article of consumption and enters largely into the everyday dietary of the people. It is cooked by itself and then eaten as such or more often in mixture with other ingredients in the shape of curried soups and other Indian dishes. It must be considered as perhaps the most important proteid food among the people of South India. The chemical composition of the dhall and of the unhusked seed is as follows :—

	Moisture	Albuminoids	Fat	Carbohydrates	Fibre	Ash
Dhall	10·5	22.3	2·1	61	1·2	3 (Church)
"	15·2	22·3	1·7	57·2	...	3·6(Aykroyd)
Togare unhusked.	11·4	20.3	1·4	56·4	7·1	3·4 (Church)

The husks of the pods and the leaves beaten out at threshing time which form a valuable cattle feed have the following composition :—

Moisture—6·2; albuminoids—15; carbohydrates—54·5; fibre—14·4; and ash—10·4 (Leather).

II. AVARE (Dolichos lab-lab.)

VERNACULAR NAMES FOR AVARE: *Kannada*—AVARE; *Tamil*—MOCHAI; *Telugu*—ANUMULU; *Malayalam*—MACHAKOTTA: *Hindustani*—BALLAR.

'Avare' is one of the important field beans of South India and is very largely grown in Mysore. In the dietary of the working classes in Mysore with whom ragi is the staple cereal food this bean is almost a daily ingredient, supplying as it does the protein supplement to the cereal grain. It is a crop cultivated almost entirely as a dry crop and in regions where the rainfall is about 25 to 35 inches; in regions of heavy rainfall like the malnads the crop does not thrive. It is a widely cultivated crop in India and can be grown even at high elevations of about 6,000 feet.

Cultivation.—The crop is grown almost invariably as a mixed crop, the main crop being ragi. The preparation of the field for the ragi crop—which has already been fully described—applies to this crop also. Along with ragi this crop is sown in the months of June—July; the sowing is carried out either simultaneously with the ragi, in which case it is sown through a one furrow seeddrill, the 'sadde' tied behind the twelve tyned ragi drill, or is sown separately after the ragi has been sown broadcast, being dropped into plough furrows drawn about six feet apart. The crop shares during its growth the same interculturing, weeding and thinning operations which are carried out for the ragi crop. It makes only moderate growth during the time that the ragi occupies the ground but soon after the ragi is harvested the growth of the 'avare' goes forward quickly and flowering commences very soon thereafter which is generally about the middle of the month of November. It is a semi-climbing low bush and under conditions of good rainfall will cover practically the whole ground between the rows. The flowers are borne on a straight upright stalk often a foot high on which they open successively. The pods are gathered both in the green stage and in the ripe dry stage. Very large quantities are gathered and sold as a green vegetable, the seeds which are three-quarters ripe at this stage being removed from the pods and cooked and eaten much like green peas. The ripe dry pods are then harvested both as pods and by cutting and removing the plants themselves. A good quantity of the green haulms and leaves is sold as green fodder but the bulk is used on the farms themselves as green feed for the cattle and what remains is dried and stored inside straw stacks for use as dry fodder. The ripe dry pods are then put out to dry still further in the sun and are either beaten out to separate the seeds or are put under the stone threshing roller and threshed. Grown as a

mixed crop about 400 lb. of dry seeds can be expected as the yield per acre. A Mysore seer of the seed will weigh 2·4 lb.

Botany and varieties.—The field bean or 'Avare'—*Dolichos* lab-lab--is a leguminous plant belonging to the sub-order Papilionaceae. It is classed as a sub-tribe Euphaseoleae, under one of the main tribes, *viz.*, Phaseoleae The plants are twining sub-erect herbs, with pinnately trifoliate leaves, with racemose flowers, corolla of various colours mainly pink and white, standards with inflexed auricles at the base, stamens diadelphous, keel obtuse, style thickened, and beard along the inner face. The pods are oblong, about three inches in length and with 4 to 6 seeds in each. A number of varieties are recognised, though in general cultivation they are not grown separately. The varieties are distinguished by the shape, size and colour of the seeds. In shape some are almost rounded, some are flattish while others have an intermediate shape between the two. In colour many variations can be seen, from creamy white, yellowish brown, to deep brown and even black. The flowers are of two colours mainly, one a brilliant white and the other pinkish or mauve; the latter is considered inferior in yield and in quality. The varieties are also distinguished in respect of taste, suitability for various dishes, keeping quality and so on; the subject has however received little or no attention so far.

Pests and Diseases.—On the field the young crop is damaged by the caterpillar and the grasshopper pests, the control measures against which have already been described. At a later stage when the pods are forming, the crop is subject to the attacks of aphids, bugs and pod-boring grubs. These pod-boring grubs form the most serious pest of 'avare', reducing the crop both in quantity and in quality. They burrow and eat into the green pods making them thoroughly unfit for sale as green pods, when the attack is very bad and seriously reducing their value even when the attack is mild. The sale value may be reduced by 25 to 50 per cent. The grubs are the larvae of five different moths, the chief among them being the *Adisura atkinsoni.* Eggs are laid on the tender pods, flowers and flower buds. The grubs hatch out and feed on the very young pod both on the surface and later, on the seeds inside, develop quickly and pupate. Broods appear in quick succession, and beginning from October some five generations are passed through in the season, *i.e.*, till January. The last brood goes intc pupation for ten months or till the beginning of the next season. The egg masses are laid singly or in rows and are easily seen if looked for. One method of control is to locate these masses and then rub them off with the hand. If the method is adopted at an early stage when the green fruits or pods are just appearing then a material reduction of the pest can be brought about. At a later stage the work becomes unmanageable. Another method of control is to spray a solution of bleaching powder made up by stirring one lb.

of the powder in 8 lb. of water, uniformly over the flower heads and pods. The colour and smell of the spray repel the moths and no eggs are laid. The tender pods grow and ripen in the meantime and become unfit for the laying of the eggs, and therefore remain healthy. A second and third spraying will have to be carried out in order to cover new flowers and young pods as they appear. The damage can be greatly reduced by the method though it cannot be altogether prevented. The smell and the colour of the spray both disappear by the time the pods ripen and are ready for picking.

A most disagreeable pest on the avare is the stinking bug—*Coptasoma cribraria*—which swarm over it in large numbers. The eggs can be easily made out, as they are laid in two parallel rows and in a strikingly uniform pattern. One method of control is to rub off the rows of egg masses. On a field scale however no satisfactory methods are known.

The 'avare' is also subject to the attack by storage pests, after it is threshed and stored. The seeds have to be dried well in the sun, cleaned and then stored in earthenware or metal receptacles under a two-inch layer of sand. As explained already, this will act as an effective method to keep out the pest. As in the case of the other pulses and grains, there are also small scale local methods which are more or less satisfactory, such as especially the tying up of the seeds in receptacles of straw twist.

Chemical Composition.—The pulse is eaten both whole fried or boiled and salted, or more generally in the form of the split pulse which is cooked and eaten. A considerable part of the pulse is sold in the form of the 'dhall' or split pulse, as in the case of 'togare.' Both husks and broken bits of the dhall are valuable cattle feeds and are fed to cows and buffaloes in milk. The whole beans are also used in this way, softened in water and mixed with other ingredients like cotton seeds, bran and various condiments. The chemical composition of the unhusked bean and of the 'dhall' is as below:—

	Water	Albuminoids	Fat	Carbohydrate	Fibre	Ash
Unhusked bean	14·6	17·1	2·2	57·4	5·0	3·6 (Church)
Do	7·1	23·3	·9	57·0	7·0	4·7 (Leather)
Dhall	12·1	24·4	1·5	57·8	1·2	3·0 (Church)

The percentage of albuminoids appears to vary considerably, due probably to variety, and according to Church the maximum range of variation was 6 per cent.

III. BENGALGRAM (*Cicer arietinum*)

VERNACULAR NAMES FOR BENGAL GRAM: *Kannada*—KADALE; *Tamil*—KADALAI; *Telugu*—SANAGALU; *Malayalam*—KADALAKKA; *Hindustani*—CHENA.

Distribution.—'Kadale' also called 'chena' is the most important pulse crop grown in India, cultivated over 15 million acres. It is said to be one of the oldest pulses known and cultivated from ancient times both in Asia and in Europe. Its cultivation as an important field crop is extensive only in India, where it extends from the North-Western Frontier Provinces down to the farthest South of the peninsula, and likewise from Gujarat in the west to the eastern limits of Bengal. Outside India this pulse is grown in many countries like Italy, Greece, Roumania, Russia, Egypt, North Africa, Rhodesia and East Africa, Iran and Turkey, in Central and South America and in parts of Australia. The larger part of the area under the crop in India lies in Upper India, where it amounts to about 12 million acres or 80 per cent of the total.

Soils.—The soils best suited are mostly clayey. The most common soil on which it is grown is the black cotton soil on which no opportunity to grow it is neglected. It is grown also on the black clayey loams favoured for rice cultivation, and very seldom on other soils. The case is, however, different in the typical gram tracts of India, *viz.*, Upper India where the predominent type is light alluvial loam.

Rotation.—'Kadale' is cultivated as a late season crop, practically after the rains of the year have ceased, the sowing season being from October to December. It grows with the help of the moisture stored in the retentive black cotton soils and of the dews which are heavy in the months following the rainy season. It grows as a dry crop almost entirely, but irrigated cultivation is also usual to some extent, the season however being the same.

It is grown either as the sole crop of the year, or more often succeeding an early crop of gingelli, coriander, early (Kar-ragi) ragi, fodder jola etc. When grown as the sole crop of the year, it is rotated with jola or wheat, or coriander. It follows rice in tank irrigated areas in years when the rains of the north-east monsoon have been poor and tanks do not receive sufficient water for rice. Grown as an irrigated crop, it is rotated with a number of garden crops like onions, sweet potatoes and irrigated wheat, jola and so on.

Cultivation.—When grown as the single crop of the year, the black cotton soil fields are ploughed after good rains have fallen and when there is a break, that is in the month of August. The bladed harrow is worked, clods broken roughly, and the field levelled somewhat; no fine tilth is attempted. About the month of October the seeds are sown in rows about ten inches apart in

plough furrows through 'saddes' and covered by ploughing an adjacent furrow. The seed rate for 'kadale' varies from 40 to 50 lbs., per acre. The crop receives neither hoeing nor hand-weeding. It has the peculiarity of suppressing weed growth. In some tracts, it is the practice to top the plants when they begin to branch, with the object of encouraging profuse branching for more flowers and fruits. The practice has been demonstrated to lead to a materially high yield of produce and is recommended. The green tops so removed form an excellent vegetable for which they can be dried and stored and cooked when required. A variation of this practice is to let a flock of sheep into the field and allow them to have a bite here and there over the field.

Rather a favourable situation for cultivating the crop are the shallow tank beds in the black cotton soil tracts and the beds of the larger irrigation tanks where, on account of poor rains, much of the usual water spread remains dry. In these situations the soil is worked only once with the heavy bladed harrow and the grain is sown in rows about a foot apart in plough furrows. The light bladed harrow is worked to cover the seed. No further cultivation is given either as a hoeing or as a hand weeding. The crop grows luxuriantly in these situations.

Similarly, good crops are grown on rice land also. The fields are ploughed and prepared to a rough tilth and in the month of November or December the seeds are sown broadcast and ploughed in; with the sub-soil moisture and the dews of the cold months the crop makes very good growth.

Collecting Acids from the Leaves.—The leaves and pods of the 'kadale' on the growing crop are coated with a thin film of vegetable acids (oxalic and malic) either encrusted on them or dissolved in the dews which settle on the plants in this season. These acids give a sour taste to the leaves and pods, and also adhere to the hands and feet of people working in or handling the crop. These acids are considered to possess medicinal properties and are collected and sold. For this purpose a thin clean piece of cloth like muslin is spread over the crop at night and into this the acids dissolved in the night dews soak. The cloth is wrung out in the morning and the liquid collected in bottles for sale. On a large scale the cloth, after it has absorbed the acid, is soaked in water and then wrung out, and this process is repeated for several days until a concentrated solution is obtained, which is allowed to evaporate in the sun and crystallise. The liquid which tastes like vinegar is prescribed for indigestion, costiveness and other bowel complaints. These acids so collected consist of 90—96 per cent of malic acid and 4—9 per cent of oxalic acid, the remainder being volatile acids. As much as 4 to 4½ lbs. of acid can be obtained from an acre of the crop.

Before harvesting the crop great quantities of the plants are pulled out when the pods are about three-quarters ripe and sold for the sake of these green pods which are eaten both raw and

cooked. In the season large quantities are brought for sale both to the towns and to the village markets.

In three months the crop matures and a good portion of the leaves become reddish brown and dry and shed on the field. The plants are pulled out by the roots and carted to the threshing floor. They are stacked for about a week, then dried and put under the feet of oxen to be trampled and threshed. It is also usual to beat the grains out by means of sticks. The dry broken pods are collected separately for being used as cattle food while the leaves and the stems are mixed in the general straw stack.

Yield.—Very good yields are obtained amounting to 1,600 lbs., per acre. An average crop may yield 1,000 lbs., while a moderate crop yields up to 600 lbs., per acre.

Botany and varieties.—'Kadale' belongs to the Natural Order Leguminoseæ, and the sub-order 'papilionaceæ' and is botanically named "Cicer arietinum" from the fancied resemblance of the seed to the face of a ram.

The plants are small much branched shrubs about one foot in height seldom exceeding 1½ feet. The leaflets composing the pinnate leaves are very small, six millimeters in length and four in breadth with serrated edges and covered with glandular hairs. The plants have a bluish green colour with a little ashy grey bloom over the leaves and stems. From the glands in the leaves is secreted the acid fluid to which reference has been already made. The plants have a definite tap root from 6 inches to a foot in length with generally four rows of lateral roots. The roots are covered with the nodules characteristic of the leguminous plants. The flowers are solitary and formed in the axils of the leaves. They possess ten stamens which are diadelphous with anthers which are two-celled. The ovary is superior with a terminal bent style and blunt stigma. The flowers are as a rule self-fertilised, but cross-fertilisation also takes place due to insect agency to the extent of some five to ten per cent. The fruit is a legume about an inch in length and ¼" across, containing usually two seeds.

Several distinct varieties exist which differ in the colour and size of their flowers and of the seeds. According to the differences in the appearance of the seeds, four varieties can be distinguished, *viz.*, the seeds being brown, yellow, black and white in the different varieties. The first three are smaller in size than the white-seeded one which is very much larger. They have also a somewhat wrinkled appearance with a beaked end. The white seeded one is more smooth and the beak too is not so prominent. The name 'Kabul gram' is sometimes given to this variety. This varity is a heavy yielder and may be said to yield more than any of the others. It is also reckoned as high in quality, and fetches a higher price than the others. Chromosome studies make it appear that it is sufficiently distinct to be classed as a different species altogether.

Pests and Diseases.—'Kadale' and all the pulses generally are difficult to preserve as they are very much subject to the attacks of the weevils attacking stored grains. They are preserved in receptacles made of straw twist of rice straw which are made in the shape of baskets. The pulses are mixed with some of the chaff derived from their own pods or of the grain 'navane' (Setaria italica) with some chilli powder and are tied up tightly and very securely in these receptacles. The effect of keeping the pulses covered under a layer of sand is also known in certain villages, where they are kept in pots or closely woven baskets, covered by a layer of sand. This is an effective and simple method and the way in which weevil attack is warded off in the process has already been explained under Jola.

The young pods are eaten into by pod-boring grubs, which reduce many of these into empty shells. It is, however, seldom that the damage is caused to a serious extent.

The standing crop itself is subject to a wilt disease. Whole plants here and there on the field dry up generally at the flowering stage or a little later and cause a reduction in the crop. Sometimes the incidence goes up to as high as 75 per cent, causing serious loss; work has been in progress to breed wilt resistant strains and at least one such strain Dharwar No. 18 has been evolved, which in comparative trials has shown only one per cent wilted plants as against 74·4 in the local strain. Similar work in the other provinces has also resulted in many types which have been found to be resistant in their respective conditions.

In the Punjaub, Bengal gram is largely subject to a kind of fungus disease to which the name 'gram blight' has been given. In seasons favourable to the disease the crop which has been attacked, is wholly destroyed. The disease is borne in the seed and the infection generally comes from the debris of the diseased crop. A thorough cleaning up and burning of all such debris both in the field and in the threshing floor, and the sowing of seed obtained from disease-free localities are the control measures which have been found successful. A strain which is found to be practically immune to the disease has also been discovered.

Bengal gram is also subject to a peculiar condition in which the flowers are sterile and do not set seed.

Chemical Composition and Uses.—Bengal gram is an extensively used pulse crop. It is eaten boiled, fried and parched. Ground into flour it is one of the chief ingredients together with ghee and sugar in many forms of Indian confectionery. The parched gram together with puffed rice or flaked rice and jaggery is widely eaten as a snack, especially on long journeys, as a substitute for cooked food. In Upper India it forms an important horse food for which purpose it is used raw and soaked in water. The skins and broken bits of the fried gram are

common cattle feed, like the husks of the pods and the dry stems and leaves obtained at threshing time.

The chemical composition of the gram is as below :—

...	Moisture	Albu-minoids	Fat	Carbo-hydrates	Fibre	Ash
Bengal gram	11·4	18·6	4·8	56·3	6·2	2·7 (Leather)
Do ...	9·8	17·1	5·3	61·0	3·9	2·7 (Aykroyd)
Bengal gram roasted and without skin	11·2	22·5	5·2	58·9	...	2·2 (do
Bhusa ...	10·1	4·5	...	38·8	27·6	19·0 (Leather)

IV. HORSEGRAM (Dolichos biflorus).

VERNACULAR NAMES FOR HORSE GRAM: *Kannada*—HURULI; *Tamil*—KOLLU; *Telugu*—ULAVALU; *Malayalam*—MUTHIRA; *Hindustani*—KULTHI.

Horsegram is the most extensively grown pulse crop in South India, corresponding in this respect to the Bengal gram (gram) crop of Northern India. While the other pulse crops of South India furnish the proteid supplement to the grain crops used as human food, the horsegram furnishes the concentrated feed for cattle supplementing the bulky straw fodders.

It is grown as a dry crop almost invariably and under conditions of only a moderate rainfall not exceeding about 35 inches. In tracts of higher rainfall it is sown after the rains have ceased, growth being due to the soil moisture helped by the dews of this season.

Soils.—It is grown over a wide range of soils, in fact there is no type of soil, excepting the badly alkaline soils, on which it is not sown. Good deep red loams, black cotton soils, clayey rice land soils, stony and gravelly up-land soils, rough jungle cleared and being newly brought under cultivation can all be sown with horsegram. It is a kind of preparatory crop on new land, two or three of which are taken before the land is put under ragi, jola or other grain crops. All fields which either on account of want of timely rains or pressure of other work could not be sown with the grain or other crops of the main season are hastily prepared and sown with horsegram. It will be considered as a very bad year indeed, almost a famine year, when even a crop of horsegram cannot be sown. In addition to these special circumstances making it an all but universal crop, the ordinary rotations also include horse gram as a crop to be grown regularly and on well prepared soils.

Rotations.—Horsegram is a late season crop being sown not earlier than September; from the beginning to the end of September is the best period for sowing, which however may be prolonged upto the beginning of October. This makes it possible to be raised as a second crop in many tracts. It usually follows an early crop of ragi, jola or gingelly; very often the crop is drilled in a standing crop of castor after the intercultivation is finished. To save time it is drilled in between the rows of even groundnuts, before the latter are harvested. Horse gram is more generally grown as a single crop of the year, in rotation with the cereals, jola, 'save' and 'sajje'. In the early season of April and May too it is sown in rice fields but more as a green manure crop preparatory to the following rice crop than for the sake of the produce.

Cultivation.—Horsegram is sown in rows and is also broadcast. In the first case it is sown in plough furrows about nine inches apart and covered by the adjacent furrow, or through the three coultered jola seed-drill and covered by working the light bladed harrow. For broadcasting, the field is divided into long narrow strips of about ten feet width by means of plough furrows, seeds are sown broadcast in the strips successively and the sowing is followed by ploughing to cover the seed. Sometimes owing to the lateness of the season and want of time to prepare the field properly, this covering of the seed by ploughing is the only ploughing the field receives. Where the crop is sown in rows and in time, the field is once inter-cultured. Horsegram is sown in many places with a mixed crop of niger, which is sown in rows about three to six feet apart simultaneously with the horsegram. The crop is always sown thick, a seed rate of 40 lbs., being common.

The plants are thin leaved partially climbing bushes reaching a height of only a foot, and they come up thick and cover the ground completely under normal conditions. The crop is looked upon partly as a source of green fodder; some slight grazing by sheep is permitted and every evening several headloads of thinnings are carried home as green fodder for sheep and cattle. The mixed crop of niger is used in the same way to a certain extent.

By the time the pods mature and the crop is ready for harvest a considerable part of the leaves dry and drop on the field. Weed growth is also profuse on these poorly prepared fields and many of them mature seeds by this time which either shed in the fields or become mixed with the horsegram at threshing time. The plants are harvested by being pulled out whole; they are removed to the threshing floor, stacked for a week, put out to dry and then threshed by being trampled under the feet of oxen or with the stone threshing roller. Both the haulms and pods are stacked together, either in straw stacks or separately.

Yields.—A good crop of horse gram will yield at the rate of 600 lbs., per acre, but yields are generally low owing to the poor attention the crop receives and the belated sowings. About 150—300 lbs, per acre is all that is obtained under these conditions. The produce requires a great deal of cleaning by means of winnowing and sifting in order to remove the seeds of the various weeds. The weight of horsegram per Mysore seer is about 2·6 lbs.

Botany and Varieties.—Horsegram—Dolichos biflorus—belongs to the natural order Leguminoseæ, the sub-order Papilionceæ and the tribe Phaseoleæ. The plants are thin, climbing bushes from 12″ to 18″ in height, with slender stems and many branches springing from the base of the plants. All parts are grey pilose. The leaves are petiolate and pinnately trifoliate, with a conspicuous stipule. The petioles are about 2″ long and the leaflets are yellowish green in colour, about 1¾ inches long and obliquely ovate acute and mucronate. The racemes arise from the axils of most of the leaves. and bear small light cream-coloured papilionaceous flowers with linear retuse wings, a slightly falcate obtuse keel, diadelphous stamens sub-equal anthers, white pilose ovary and style and capitate stigma. The pods are thin about 1½″ to 2″ long and ¼″ broad, with seeds which are brown, light red, black or mottled in colour according to variety, flattened and with a hard shiny seed-coat. The cultivated crop is usually a mixture of most of these varieties. The black-seeded variety is of a shorter duration than the others.

Pests and Diseases.—Horsegram is subject to the attacks by the pests of stored grains and has to be preserved in the manner already described. The growing crop is attacked by the hairy caterpillar and grasshopper pests and the remedies are the same as described under Ragi and Jola.

In the field the growing crop is subject to a root rot which is sometimes serious and kills off many plants. Other diseases like the bean rust, anthracnose, die back are also seen, especially the "die back". The damage from none of these except the 'root rot' is serious at any time. Even the 'root rot' appears over a large area only when owing to heavy rain or flooding by irrigation water, the soil becomes very moist, and this contingency arises only rarely.

Chemical Composition and Uses.—Horsegram is the poor man's pulse crop and is eaten both boiled and fried. In contrast with other pulses, horsegram is not converted into splitpulse, but is used as such. It is as a food for cattle and horses that it is more largely used. Working animals invariably receive horsegram as part of their ration at the rate of some 4 lbs., per day per animal. It is given boiled or slightly parched and broken. When fed to horses it is invariably boiled whole.

The seed coat is hard and animals pass out in their excreta more or less of this feed quite unaltered.

The chemical composition of horse gram is as below :—

Moisture	Albuminoids	Fats	Carbohydrates	Fibre	Ash	Remarks.
11·8	24	1·3	57·3	5·3	3·1	Aykroyd
11·0	22·5	1·9	56·0	5·4	3·2	Church
7·5	20·1	0·9	60·6	4·6	6·4	Leather

According to Church the ash of this gram contains 1/3 of its weight of phosphoric acid.

V. BLACKGRAM (Phaseolus mungo).

VERNACULAR NAMES FOR BLACKGRAM: *Kannada*—UDDU; *Tamil*—ULUNDU; *Telugu*—UDDULU, *Malayalam*—UHUNNU; *Hindustani*—UDID.

Black gram is one of the important pulse crops grown throughout India.

Soils.—It is grown principally on soils inclined to be clayey and on the black cotton soils, on which it does best. Red loams, light red or brown alluvial soils and other types are also put under the crop, where these form the predominent soils, and where they are not shallow.

It is grown almost entirely as a dry crop, in tracts with a rainfall not exceeding about 35 inches: in the tracts of heavier rainfall it is raised only in the season following the cessation of the rains. On rice fields it is raised either previous to or after the rice crop; in these fields although it is raised as a dry crop an irrigation or two may be given, if available. It is grown not only on the plains but at elevations even up to 6,000 feet. On the Mysore plateau with its mean elevation of 2,500 to 3,000 feet it is one of the important pulse crops grown.

Rotation.—Blackgram is grown in two seasons, *viz.*, as an early or midseason crop or as a late season crop. As an early season crop it is sown in the early part of May, as a mid-season crop in June or July and as a late season crop in the month of October. Except in the tracts where the rainfall is usually confined to the late season, *i.e.*, in the North-east monsoon, the blackgram crop follows or is followed by another crop, so that usually two crops are raised one of which is blackgram. The crop is one of only three months duration and so makes this double cropping in the same year possible. In tracts of the late rains however only one crop is raised in the year. In the early season tracts, the blackgram is followed by gingelli or main season ragi on the red soils; and by wheat, coriander, late season jola and other cereals on the black cotton soils.

When grown on rice fields, it is considered partly as a green manure crop preparatory to the following rice crop, but generally

if early showers are received or if a watering can be given, then the seeds are sown sufficiently early for harvesting a crop; otherwise only the pods are gathered both ripe and unripe without waiting for a normal crop, and the plants then ploughed in for manure after some amount of grazing. In the Malnads or tracts of heavy rainfall, the blackgram is grown on the rice fields after the rice is harvested and the moisture in the soil is generally found sufficient to mature a crop. If irrigation is possible and is found necessary as may be the case on shallow soils and when the crop was sown late, one or two irrigations may be given.

In all the above cases the crop is generally grown pure; but rows of fooder jola, safflower or linseed may be grown as mixed crops. A good deal of blackgram is also sown as a mixed crop in the main season jola, especially on the black cotton soils as already mentioned under 'Jola'. When grown as a partial green manure crop preparatory to rice it is often grown mixed with a small quantity of sannhemp, cowpeas, greengram and horsegram.

Cultivation.—In all cases the fields are prepared by about two ploughings, or just one ploughing followed by working with bladed harrow or cultivator. Nothing more than a rough tilth is attempted. For the early crop the ploughing begins in the month of April and sowing takes place in May while for the later season the ploughing is in August or in the middle of September or early in October.

Seed is generally sown broadcast and ploughed, or sown in rows about 10 inches apart in plough furrows and smoothed by a harrow. In seven days to ten days the plants are well above ground. Interculturing with toothed hoes in the former case and with either toothed hoes or bladed hoes in the latter case is given once after three weeks. No such interculturing is however given when the crop is grown on the rice fields. In about seven weeks the plants commence to flower and in three months the pods are ready for gathering. The plants are pulled up by the roots, stacked in the threshing floor for a week and threshed by beating with sticks or under the feet of oxen. The seeds are dried, cleaned and stored in straw baskets or in earthenware or metal receptacles under a layer of sand. Like other pulses it is also subject to weevil attacks and has to be protected in the manner described already for stored grains. The husks of the pods are preserved in the straw stacks as fodder, while the stalks are used as fuel or manure.

Yields.—The yields vary a good deal according as it is grown pure, or as a mixed crop or for green manure. An average pure crop will yield about 400—500 lbs., per acre.

Botany and Varieties—.The blackgram belongs to the order Leguminoseae and the sub-order Papilionaceae. The plants have a strong tap root with many laterals with typical root nodules on them. They are small shrubs of about a foot in height, diffusely branched, with leaves and stems covered with

rough reddish hairs giving the plants a dark green appearance. The flowers are borne in the axils in elongated racemes and are yellow in colour. The pods are long, slender and cylindrical, about 1½ to 2½ inches in length, and septate between the seeds which vary from eight to fifteen in number. The seeds are either black or very dark brown or occasionally even greenish. The latter however can be distinguished from the greengram proper by the colour of the split seed, which is white in the blackgram and yellow in the greengram.

Two varieties are distinguished in blackgram which are sharply restricted each to a particular season. One is small-seeded and the other is slightly larger and in Mysore are called the small and large 'Uddu' respectively. The small-seeded one is sown in the early monsoon and the large variety is sown in the late monsoon. The large-seeded variety is locally regarded as the better of the two.

Chemical Composition and Uses.—Blackgram differs from other pulses in its peculiarity of attaining when ground up with water a somewhat mucilagenous pasty character which increases as the grinding is continued and made finer, giving additional 'body' to the mass. Like glutens in wheat, this property of the blackgram increases the 'raising' in the various cakes made from it, and lightens them. Both variety and soil seem to influence this property and the blackgram from particular tracts is reputed to excel in this quality. The proteids in blackgram are also probably different from other pulse proteids and comparable to proteid from animal sources, as the popular opinion is that the preparations made out of the blackgram can be mistaken to contain meat and that blackgram began to be popularised by Buddhist monks as a substitute for meat which that religion of mercy strictly tabooed.

As a cattle feed, blackgram added to other materials like cotton seed, bran and so on in the ration is said to increase the flow of milk.

The chemical composition of blackgram is as below:—

—	Moisture	Albuminoids	Fats	Carbohydrates	Fibre	Ash	Remarks
Blackgram (without skin).	10·9	24·0	1·4	60·3	...	3·4	Aykroyd
Blackgram whole ...	8·1	18·5	1·0	59·1	4·3	4·5	Leather

According to Aykroyd the blackgram is the richest among the various pulses (grams) in phosphoric acid, being five to ten times richer than in the others.

VI. GREENGRAM (Phaseolus radiatum).

VERNACULAR NAMES FOR GREENGRAM; *Kannada*—HESARU; *Tamil*—PACHAIPAYERU; *Telugu*—PACHAPESALU *Malayalam*—CHERUPAYERU; *Hindustani*—MUNG.

Greengram is another important pulse grown throughout India. In the range of distribution, in soils, and climate suited to it, and the general methods of cultivation, it is very similar to blackgram. Botanically too they are very closely related; in fact the specific name 'mungo' is applied by certain writers to this pulse and not to the blackgram.

The plants are less hairy and in appearance less dark and more green and slightly taller than the blackgram plants. The flowers are a lighter tint of yellow, the pods are smaller and the seeds are green in colour and smaller in size. The split pulse is yellow in colour as against the white or pale cream of the blackgram.

The greengram is cultivated in both the early and the late monsoons, for which latter there is a different variety; there is however one variety which can be sown in both seasons. Like blackgram it is sown in rice lands partly as a green manure crop and partly for the sake of the produce. Its place in rotations on both red and black soils is also similar to that of the blackgram. There is however not the same preference for the clayey type of soils as in the case of the blackgram and all the prevailing types are availed of.

In fields prepared as for blackgram, the seeds are sown either broadcast and ploughed or harrowed in or sown in rows in plough furrows some ten inches apart and covered by a smoothing harrow. It is sown as the main crop by itself or with fodder jola as a mixed crop; it is also sown as a subordinate mixed crop with jola. On rice land when intended partly for green manure purposes other quick growing leguminous crops like blackgram, horsegram, cowpeas, and sannhemp are sown as mixtures. On rice land when the crop is to follow rice it is sometimes sown broadcast in the moist rice land a few days before the rice crop is harvested, in order to save time, so that a crop may mature before the soil dries up and the moisture becomes too little for the crop. The seed rate for the crop when sown by itself is about 15 lbs., per acre. In about a week or twelve days the plants are up and the braids well seen. The crop is hoed after twenty days by interculturing tools once and sometimes also hand weeded later. In 70 days the green pods are ready to pick and in another three weeks or a month the pods are dry and the crop is ready to be harvested. A fair amount of green pods is however gathered for sale and for use at home as a vegetable,

when the crop is about nine or ten weeks old. The plants after harvest are removed to the threshing floor, and are stacked for a week. They are then threshed by beating with sticks or trampling under the feet of oxen. The empty pods and chaff are preserved as fodder inside the straw stacks.

Good crops yield some 300—500 lbs., of greengram per acre. Sown as a mixture or as a partial green manure crop yields are low and uncertain, but about 100—200 lbs. per acre are expected.

Greengram enters into a variety of preparations in South Indian kitchens. The husks are usually removed and the split gram is boiled, fried or ground into flour as may be required for various dishes. The grain is also parched whole and eaten by itself or mixed with other pulses similarly parched and salted or sugared. Greengram is esteemed as the most wholesome among the pulses, free from the heaviness and tendency to flatulence which is associated with the latter. The husks of the gram are fed to cattle either soaked in water or dry.

The flour of greengram is often used as a substitute for soap or soapnut powder in Indian households especially for children. The pulse is badly subject to the attacks of weevils and the special method of storage for keeping out the pest covered by a layer of sand, in earthernware or metal receptacles is particularly necessary in the case of this crop.

The chemical composition of the greengram is as below :—

Moisture	Albuminoids	Fat	Carbohydrates	Fibre	Ash	Remarks
10·4	24	1·3	56·6	4·1	3·6	(Aykroyd).
10·3	22	2·7	54	5·8	4·4	(Church).

VII. COW PEAS (Vigna catiang).

VERNACULAR NAMES FOR COW PEAS: *Kannada*—ALSANDE; *Tamil*—KARAMANI; *Telugu*—ALSANDALU; *Malayalam*—MAMPAYARU; *Hindustani*—LOBIA BADA.

The cow pea is a pulse crop of very minor importance both in respect of the area cultivated and of the demand and consumption among the people in Mysore and South India generally. It is remarkable, however, that outside India it is probably the best known and most extensively cultivated among all the Indian pulses, although it is thus grown not for the sake of the pulse to be used for human consumption or for cattle feed but for the sake of the heavy growth of green material which it gives and which is used as a green fodder, as dried hay, as a green manure and as a soil improving cover crop. It is regarded as native to India and the countries to the north-west in Central Asia.

Its cultivation now extends to many parts of the world, even up the 40th lat. N. where the warm summer admits of its growth, although the crop does not mature seed in these cold latitudes and affords only forage to stock. In the U. S. A. especially it is a crop much esteemed for these purposes and its cultivation can be seen even in the far northern States, while in the warmer southern and south-western States it is a very popular crop, not only cultivated very largely but also studied in its many aspects.

Like most pulses in South India, the cow pea is grown mainly as a rainfed crop. It is, however, capable of withstanding a much higher rainfall than the others and on this account can be grown in the malnads of Mysore also, where as a matter of fact it is the chief pulse grown and takes the place of the usual maidan tract pulses. It is grown largely as a mixed crop, with ragi or jola in which a few rows here and there are occupied by cow peas. Occasionally pure crops are grown on a small scale, chiefly on rice fields after the harvest of the rice in the hot weather, with the help mainly of the sub-soil moisture, sometimes supplemented by irrigation.

It can be grown on a variety of soils; good red loams, the black clayey loams of the rice fields, the black cotton soils, coarse gravelly soils and light sandy soils, are all utilised and on all but the last two types, the crop makes very luxuriant growth. In the colder climates somewhat light and sandy soils are preferred, on account of the fact that on such soils maturity is hastened.

Cultivation.—The crop is usually grown as a main moonson crop, like the chief dryland grain crops ragi and jola, with which it is sown as a mixed crop. It can, however, be also sown as an early monsoon, or a late monsoon or even as a hot weather crop. There are varieties suited to these different seasons and sowing in the wrong season for any particular variety leads to an inordinate vegetative growth of tangled creeping branches. The field is prepared for the grain crops with which the cow pea is to be sown as a mixture and so the crop has the advantage of a well prepared soil. Simultaneously with the ragi or jola, the cow peas are also sown, in rows about six feet apart. Sowing is either through the 'sadde' or seed tube tied behind the seed-drill or in plough furrows made after the grain crop is sown. These rows are sown either solely with cowpeas or the cow peas are mixed with one or more of the different crops used for this purpose such as, 'avare', 'pundi', fodder jola, sannhemp, niger, etc. In the latter case it forms only an insignificant part of the crops sown, and is intended more or less for using the green pods as a vegetable. The seed rate therefore varies greatly, and may be taken roughly as 6 lbs. per acre if sown pure in six feet rows in the ragi or jola crop. If sown by itself as is done occasionally, the seed rate will amount to 20 or even 30. lbs per acre. The seeds germinate readily and are

well sprouted on the third day. The braids with the true leaves can be seen in another five or six days. As regards weeding, interculture and so on, the crop shares these and all other attention with that bestowed on the main grain crops. It is a quick grower and has an abundance of sappy twining stems and leaves. In six weeks the flowers begin to appear and in another two weeks the green pods are ready for being gathered as a vegetable. The crop goes on fruiting irregularly in succession and the ripe pods are ready for harvest in about three months. There are longer duration varieties which do not finish fruiting for five months just as the short duration varieties finish fruiting in three months. The varieties usually sown are of the longer duration class and require frequent gathering of the pods as they ripen. As the crop is sown as a mixed crop in very indefinite proportions the yields per acre are difficult to estimate; but the produce can be reckoned generally as about forty to fifty times the quantity of the seed sown. Little more than 100 or 150 lbs. are, however, obtained in the usual method of mixed cultivation.

Cow peas are also cultivated solely for green feed for cattle and for this purpose are sown mixed with fodder jola. The creepers wind round and climb on the jola stalks and both the crops are cut down together and fed.

Botany and Varieties.—The cow pea (Vigna catiang) belongs to the natural order Leguminoseæ, the sub-order Papilionaceæ and the tribe Phaseoleæ, It is an annual sub-erect plant with the stems growing as thin succulent long twiners, requiring in some types an upright or standard for support, but generally spreading on the ground as a bush about three feet in height. The stems are thin and rounded, rough in some and smooth in other varieties, and generally free from hairs except at the nodes. The leaves are pinnately trifoliate with a long petiole and the leaflets are large, dark green and ovate acute in shape. The inflorescences arise from the nodes and are racemes, with a long ped-uncle; the flowering part is nodose and bears from three to six flowers, white, light pink or light blue in colour according to variety, and are sub-sessile. The flowers are large, about 1 inch across and very conspicuous both in size and in colour. The colour varies in different varieties and is light blue in some and light pink in others, with the inside of the wings turning yellow as they fade. The pods are rounded and thin and vary in length in the different varieties. The longest pods are quite 18 inches to 2 feet in length, while the shortest are about 4 to 5 inches. The seeds likewise vary in size and colour, the large-seeded kinds have seeds twice as large as the small-seeded kinds; in respect of colour seeds are cream coloured, brown, dull red, light purple and even black according to variety.

Many varieties are met with in South India but these have not been studied and classified. In Bombay nine varieties are

listed and their differences in respect of length of pod and colour of seed noted by Gammi. In the U.S.A. the crop has been very much studied and the varieties have been named and described with regard to their habit of growth, duration of growth, colour and size of pod, and the colour and size of the seeds. A very useful American variety is the one called "Iron Cow pea" which has been found to be wilt-resistant.

Pests and Diseases.—Like most of the pulse crops the cow pea is subject to the attacks of several insect pests, such as leaf-eating caterpillars, sap-sucking bugs, plant lice and a stem-boring maggot. In addition to these field pests, cow pea seed is badly subject to the attacks of weevils common to pulses in storage. Many of the pests of the standing crop can be controlled by spraying or hand-picking in the early stages, although the very minor importance of the crop seldom justifies any great expenditure. The stem-boring maggot causes great damage as it attacks the plants when they are very young; the parts of the plant above the attack become yellow, the stems and leaves wilt and the plants die. The attack is caused by a fly—*Agromyza phaseoli*, C.—the female of which lays eggs in the epidermis of the soft stem, where inside the somewhat swollen base they hatch, burrow and breed, causing the wilting and death of the plant. No satisfactory remedies are known.

The store house pests of pulses have already been described and the control measures are the same as in the case of the other pulses.

Diseases.—Cow peas are subject to attack by (1) a rust (*Euromyces appendiculatus*), (2) powdery mildew (*Erysiphe polygoni*), (3) anthracnose (perhaps (*Glomerella cingulata*), (4) Root rot (*Rhizoctonia sp.*) and (5) a die-back (*Vermicularia capsici*). The rust and the root rot may be considered the most serious among these diseases. As far as the rust is concerned there is no effective remedy known and the only relief lies in the growing of rust proof varieties. The "Iron Cow pea" is reputed to be resistant. The anthracnose can be controlled by spraying with Bordeaux mixture which should be carried out as soon as the leaves show signs of attack. The root rot is not amenable to any control measure, as the fungus persists in the soil. The only method of avoiding it is by a suitable rotation of crops. The die-back yields to spraying with Bordeaux mixture, especially if the new growth which springs up after the top dies is sprayed repeatedly and kept free from the fungus.

Chemistry and uses.—The cow pea is a highly nutritious proteid food. It is used both for human consumption and as a concentrated feed to cattle. The chemical composition of the pulse is as follows:—

	Moisture	Proteids	Fats	Carbohydrates	Fibre	Ash
Indian sample	12	24·6	0·7	55·7	3·8	3·2 (Aykroyd)
American „	14.8	20·8	1·4	55·7	4·1	3·2

The crop gives such a heavy vegetative growth and covers the ground so well smothering all weeds that it forms a very good cover crop and can later be ploughed in as green manure. The plant foods contained in the crop are as below:—Entire plants dried to a moisture content of 11 per cent contained 1·95 per cent nitrogen, 0·52 per cent phosphoric acid, and 1·47 per cent potash.

The crop forms excellent forage, both for cutting and stall feeding and for making into hay or silage. For the making of silage, the crop has to be mixed with at least the same weight of fodder jola or maize stalks.

SECTION III.

OILSEEDS

I. SESAME (Sesamum indicum).

VERNACULAR NAMES FOR SESAME: *Kannada*—WOLLELLU, *Tamil*—YELLU; *Telugu*—NUVVALU; *Malayalam*—YELLU; *Hindustani*—TIL.

Distribution.—Sesame or gingelli is an oilseed which furnishes one of the most important oils of domestic consumption in India. It is one of the oldest oilseeds of the world. It is said to be native to India, and the provinces to the north of the Himalayas with temperate climates, though its origin is sometimes traced to Africa and sometimes to the East Indies. Its cultivation at the present time is over a very wide range of conditions both in the tropical and sub-tropical zones of the globe. India is, however, the largest producer of the crop and China comes next in importance, but other Asiatic countries like Siam, Indo-China, Formosa, Japan, Palestine, and Turkey and the countries of the Mediterranean sea-board in Europe, Russia, Brazil, Argentine and Mexico and the whole of Africa, notably Egypt, Sudan and Nigeria, all grow the crop on large areas.

Gingelli grows on the plains and at elevations upto 4,000 feet. It is grown in the somewhat warmer part of the year with the prevailing temperatures about 70°F., and above. It is grown generally solely as a rainfed crop in tracts where the rainfall in the crop season does not fall below 20 inches.

Soils.—The soils best suited for gingelli are light sandy loams, the growth being better as the sandy portion increases. In practice, however, it is grown on a variety of soils provided there are no definite defects. On the typical red loams of Mysore it is very extensively grown, as well as on the clayey rice fields and on the black cotton soils.

Rotation.—The gingelli crop takes from 3½ to 4½ months to mature depending upon the variety. Sown in the early season it can be followed by another crop in the same year. On such double crop areas it is followed by a crop of horsegram. On the black cotton soils it is followed by jola, coriander or wheat and even by cotton. It can be sown in the later rains also in September and October and in this case follows an early season crop of ragi, fodder jola, or black-gram. Sown however in the middle of the year about the months of June or July it is the only crop of the year and is rotated with ragi or jola and other dry crops. On the rice fields it is very generally grown in the early season

somewhat like the green manure crops but the crop is allowed to mature and the produce is harvested. It is followed by a rice crop. Gingelli is considered to be an exhausting crop and the succeeding crops will have to be manured well. For this reason the growing of gingelli before a grain crop such as rice on wet land and jola or ragi on dryland is not much favoured and is condoned only if the latter can be well manured, which is thought possible because the gingelli is a valuable cash crop, and gives a good money return. In Mysore, gingelli is generally grown as a pure crop and with the rotations mentioned above; elsewhere it is grown as the main crop of the year and many crops are grown in mixture such as togare, castor, etc., or the gingelli is itself grown as a subordinate or mixed crop with 'Sajje' as the main crop.

Cultivation.—The field has to be well prepared for gingelli, by several good ploughings followed by working the bladed harrow or other cultivating tools and the harrow. The field should be well cleaned of weeds and a somewhat fine tilth produced, if really good yields are to be obtained.

Gingelli is sown broadcast or in rows. As the seeds are small it is usual to mix the seeds with sand or manure so as to avoid a too thick and uneven stand of crop. In some parts of Mysore ragi grain which has been spoiled by storage in underground pits and which has therefore lost its germinating power is used to mix with gingelli seed for this purpose. Before sowing broadcast the field is marked into long narrow strips by plough furrows and then the seed is scattered in each strip one after the other and covered by working a light wooden toothed harrow. Sowing in rows is by means of the seed-drills which sow the seeds in rows about twelve inches apart, the drill being worked rather shallow to avoid deep sowing of the seeds. The seed-drill is followed by a light wooden toothed harrow or brush harrow made by fastening together some leafy branches placed side by side to resemble thick matting.

The quantity of seed is about 1 lb. to 3 lb. per acre according as it is drilled or sown broadcast. The seeds germinate slowly and the braids are seen in about ten days; the crop is intercultivated with bladed hoes after a fortnight, when a great deal of thinning of the crop takes place. A second hoeing between the rows is given after a week, and sometimes a hand weeding also. Where the cultivation of gingelli is only of secondary importance and the crop is looked upon as a kind of catch crop, so much attention is not bestowed and the crop is left much to itself with the result that both growth and stand are very uneven, thick in one place, thin in another, and luxuriant in some spots and stunted in others. In 3½ to 4½ months the crop is ready for harvest. Both leaves and stem yellow slightly and the leaves begin to drop also; the capsules are well filled and plump and assume a yellowish tinge. The plants are cut

or pulled out at this stage, that is to say, some considerable time before the capsules are due to burst. The plants are taken to the threshing floor and are then piled in circular stacks with the root ends outwards and allowed to remain stacked in this way for a week. The stack is then opened out and spread to dry during the day and piled up again during the night. This is repeated until the capsules begin to burst. The capsules are now well opened and dry and without any mouldiness developing. The plants are well shaken and also beaten to complete the emptying of the capsules. The gingelli seeds are now cleaned to remove the adhering earth with which at this stage the gingelli is mixed up to a very large extent. The winnowing and screening of the gingelli as it comes out of the threshing floor, to free it from dust, earth and gravel has to be very thorough and elaborate.

Yields.—The average yield of gingelli when grown as a pure crop will amount to between 300 to 400 lbs., per acre. A full crop is reckoned as 600 lbs. A Mysore seer of seed will weigh about 2·03 lbs.

Botany and Varieties.—The gingelli plant belongs to the natural order Pedaliaceæ—a small order comprising mainly herbs; botanically it is distinguished as 'Sesamum indicum D. C.,' though originally two species were recognised. The plants grow usually about 3½ feet to 4½ feet high. Giant plants are occasionally seen so large that it may be difficult to believe they were really the ordinary gingelli. These plants grow some six feet in height with thick stems. The cultivated variety is however seldom more than 4½ feet in height with a straight stem square in section with considerable branching. The leaves are dentate or entire. The flowers which are borne in the axils of the leaves are generally in singles but twos and threes can also be seen. They are curious in shape, resembling somewhat the flowers of Bignoniaceæ. The corolla is tubular and bilabiate. The flowers are variously coloured from pure white to deep violet with intermediate ones in which one or other of the two colours predominates. The stamens are four in number and didynamous and the ovary is two-celled. The fruit is a bilocular capsule, quadrangular in shape, about 1½ inches to 2 inches in length and about ½ to 1 inch around. The capsules are somewhat thicker and larger in the white-seeded variety than in the brown and black-seeded varieties. The locules are further divided making the capsule a four-celled one. In the white variety the capsules are six-celled. The capsules split and open at the top and shed the seeds which fall off easily. The seeds are small, numerous, and have a flattened oval shape. About 10 to 12 of them measure an inch across their width and about 6 to 8 of them along their length. The seeds are differently coloured according to variety, being white, dull white, light brown or dark brown and almost black.

The varieties of gingelli are distinguished not only by the colour of the seeds as noted above but also according to the season in which they are grown. Like many other crops as rice, jola and ragi, varieties of gingelli also are distinguished by their suitability to particular seasons of sowing such as early, main or late season. In Mysore the early sown variety is called 'Karyellu' and of these, one has light brown seeds and the other black seeds. The plants are tall and much branched but the yield is not so high as the main season variety. The Kar varieties are sown from the beginning of February at the earliest and up to the middle of April at the latest. They are harvested from the third week of May up to the first week of August when the harvesting is completely over. The main season varieties are sown from the middle of July, have both brown and black seeds, and are harvested from the beginning of November to the third week of the month and yield a heavier crop. The white and dull white varieties are sown only in the late season about the month of September and are harvested in December and January in about 3½ to 4½ months. The white variety is also sown in some tracts in the main season, that is, in the month of June, usually in rice land under tanks which do not receive enough water to grow a rice crop.[1] As the varieties are controlled by the season, only the varieties suited to the season should be sown. If the early season or the hot weather crop is sown in the late season, the plants will keep on growing and will not mature a crop.

Pests and diseases.—The insect pests attacking gingelli plants specially are only of minor importance. The chief among these is a caterpillar pest—*Antigastra catelaunalis*, D.—which eats the leaves and also bores into the shoots and pods. The caterpillar also folds and webs the leaves together. There are no satisfactory remedies known. Hand-picking and destroying the affected leaves and shoots will prevent the spread of the pest. Another insect pest of gingelli is the gingelli gall fly—*Aspondylia sesami*, F.—the maggots of which feed on the young flower buds, producing a gall-like malformation, which eventually drop off. The loss of the flower buds if on any large scale leads to a considerable reduction in crop. No satisfactory remedy has been found out.

Sap-sucking bugs and aphids also cause damage by arresting the growth and weakening the crop.

The gingelli crop is subject to rather severe attacks of white mildew (oidium) on the leaves. The affected leaves show numerous white patches of the grey powdery mildew and drop off after sometime. The plants receive a serious set back and the yield is greatly affected.

A common trouble with the gingelli which leads to a great reduction in the yield is a malformation of the flowers which become sepaloid and sterile. Such sepaloid flowers crowd

together at the axils and often are completely green in colour like the leaves. Such flowers do not of course set seeds and therefore cause a reduction in the crop. The conditions giving rise to this malformation are not well understood nor are any remedies known.

The leaves are also affected by a leaf spot disease—*Cercospora*—in which greyish brown to dark brown spots appear on the leaves which impair the growth of the plants. Both the mildew and the *Cercospora* appear only under special conditions of the weather and no control measures suitable for application and adoption on a field scale have been worked out.

Chemical composition and uses.—Three varieties of gingelli, *viz.*, white, black and brown, grown on the Poona Farm in Bombay had the following composition :—

	White seed	Black seed	Brown seed
Moisture ...	4·87	5·42	5·37
Oil ...	48·13	46·50	46·20
*Albuminoids ...	22·50	25·81	21·03
Carbohydrates ...	14·05	9·06	15·87
Crude fibre ...	4·49	6·52	4·18
†Ash ...	5·96	6·69	7·35
	100·00	100·00	100·00
*Containing Nitrogen ...	3·60	4·13	3·37
†Containing sand ...	0·37	0·66	1·35

The composition of the seed is however very variable, especially the oil content which varies from 35 to 57 per cent according to the varieties and the countries in which they were grown. The carbohydrates likewise vary from 14 per cent to 22 per cent and the ash from 4 per cent to 8 per cent.

Uses.—Gingelli seeds are used both directly as a human food in Indian households and as a source of an important edible oil. The seeds are eaten fried and mixed with sugar, and in several forms in Indian sweetmeats. The gingelli oil is an important cooking oil in South India and to an almost equal extent is used for regularly anointing the hair and body, a customary bi-weekly bathing practice which in South India is deemed very beneficial to health. It is also consumed raw and is really the poor man's substitute for ghee. Gingelli oil lends itself to be used as a perfumed oil as it does not itself possess any strong odour, especially after it is kept for sometime and is able to absorb the fragrant essences of sweet scented flowers. The perfume of orange and other citrus flowers and of

jasmine are extracted in this manner. In Europe one kilogram of the flowers is added to six litres of oil and left for forty hours for extracting the perfume. Many other flowers are used in this way in the Indian perfumery industry also. Gingelli oil is used to adulterate olive oil, as a salad oil in Europe. The lower grades of the oil find industrial use for the making of soap. It is used as an illuminant, but it burns out quicker than groundnut or castor oil. It finds also a number of medicinal uses.

The oil is almost entirely a non-drying oil and has the following characteristics :—

Specific Gravity at 15° C.	...	0·923
Refractive Index at 10° C.	...	1·4902
Saponification Number	...	188-193
Reichert Miesel Number	...	1·2
Iodine Number	...	103-112

The oil is made up of the glycerides of the solid palmitic and stearic acids (12-20 per cent) and of the liquid acids oleic and linoleic (88-90 per cent). The oil contains also two bodies specific to it, *viz.*, phytosterine and sesamine. Gingelli oil gives intense colour reactions with various re-agents like furfurol, and this is made use of in identifying it and detecting its presence in other oils like olive oil in which adulteration with gingelli oil is suspected. The oil remains liquid even at low temperatures of 4° C and this makes it a suitable salad oil in cold countries even better than olive oil.

The oil-cake is an edible cake. It is eaten mixed with sugar by the working classes with whom it is found to be a sustaining food. It is as a cattle food that it finds its greater use. It is esteemed as of very high value for milking animals and much higher prices are paid for it than is warranted by its composition as compared with other feeding cakes like 'groundnut cake' for instance. The composition of the cake is as follows :—

Water	Fats	Proteids	Carbohydrates	Crude fibre	Ash
11	12·8	37·2	20·5	7·5	10·9

The oil is extracted in India in the old-fashioned wooden rotary oil mills, which have in recent years been displaced to some extent by iron rotary mills. Where genuine and clear oil is required, the seed coat of gingelli seeds is removed, by steeping the seed in water and then rubbing off the seed coat which is loosened by the steeping in water. The gingelli oil of the bazaar is often much adulterated; and for this purpose gingelli is milled along with niger seed. Considerable oil is left unexpressed in the oilcake and this adds value to the cake in the opinion of Indian cattle keepers. In modern mills the

seed is pressed twice or thrice, the oil each time being clearer than the one pressed at the next subsequent milling. The last remaining quantity is extracted by chemical solvents.

Acreage and trade.—The total area in India under gingelli in the year 1937-38 was about 4·1 million acres, of which Bombay grew 160,000 acres, Madras 790,000 and Mysore 80,000 acres, and Hyderabad 560,000 acres.

Gingelli is an oilseed with a large local consumption and is not exported to the same extent as other oil seeds; the export of seeds and oil during the year 1939-40 was: seeds 3,502 tons, valued at about Rs. 7,60,000 and oil 239,996 gallons, valued at about Rs. 3,26,967. The export of seeds is however a fluctuating figure; the maximum during the previous five years was about 14,000 tons and the minimum 1,300 tons.

II. GROUNDNUTS (Arachis hypogea).

VERNACULAR NAMES FOR GROUNDNUTS:—*Kannada*—KADALEKAYI; *Tamil*—NELAKADALI; *Telugu*—NELASHANAGALU; *Hindustani*—VILAYATI MUNG, MUNGPALLI.

The groundnut crop in India and indeed in the whole world is a remarkable instance of the marvellous effect which the stimulus of a commercial demand exercises over the expansion of cultivation of any particular crop. From being a crop of very little importance and cultivated more as an insignificant food crop like one of the ordinary pulse crops on small areas, it has within the period of little over half a century been taken up for cultivation over millions of acres and practically in every part of the world except where precluded by climatic conditions, solely on account of the discovery of the number of industrial purposes for which it can be used as an oilseed. The only parallel to this development is the cultivation of the soya bean.

Distribution.—The groundnut is believed to be a native of Brazil, South America, but the chief centre from which this worldwide expansion commenced is stated to be West Africa, from which, thanks to the enterprise of certain French industrialists, it was introduced into the French colonial possessions and thereafter overflowed into other parts of the world. Though a tropical crop, its cultivation extends in both the tropical and subtropical zones and even into the higher latitudes, provided the summers are long enough to permit the crop to come to maturity. One of the most important groundnut growing regions of the world is the United States of America, where extensive areas are grown in the Southern and South-eastern States and in some of the South Central States also. The whole of West Africa including the Congo Free State, and several parts of East and North

Africa such as Mozambique are very important groundnut regions. The East Indies, Burma, and Cochin China also grow large areas. India is among the most important regions with an extent exceeding eight million acres under groundnuts. Along the Mediterranean littoral in Europe and in China, Japan and in Australia the crop is grown over considerable areas. In India the crop is grown in nearly every province but over 60 per cent of the acreage is in the Madras Province and 30 per cent in the Bombay Province, while the remaining 10 per cent is distributed over other parts of the country.

Soils.—Groundnuts are grown both as a dry crop and under irrigation. For really good yields, groundnuts require a higher rainfall than the ordinary dryland crops. About 30 to 35 inches should be considered necessary, though the crop is grown under a much lower rainfall such as 20 or 22 inches, the yield of course being correspondingly precarious and low. It can, unlike the ordinary dryland crops, also stand a higher rainfall which may go up to 50 or 55 inches. A light sandy soil, well drained sandy loams and good alluvial loams are suited ideally for the groundnut crop. These light soils favour the setting and ripening of good crops and also make the harvesting easy. Over large tracts however it is the ordinary red loams, both light and heavy that are put down to groundnuts as the predominant soils. In recent years very large areas are grown on the black cotton soils also, and on the somewhat heavy soils of rice fields. Like many popular crops it is beginning to be grown on practically all soils, unless they are positively harmful by being badly drained or alkaline or otherwise defective.

Rotation.—Groundnuts are grown generally as the only dry crop of the year. The variety largely under cultivation is one which occupies the ground for quite five months, and where the digging or harvest of the crop has to be postponed, for even a longer period; hence only one crop can be grown whether the tract is one of early rainfall or late rainfall. In recent years however, early maturing varieties which take only 90 to 100 days have come into cultivation; this has made the raising of a second crop possible in dryland cultivation also. Where the crop is raised under irrigation, groundnuts form one of the two crops raised in the same year. The long season groundnut crop is rotated with ragi sown as a main season crop. The rotation is rather recent but it is found very advantageous, especially on account of the digging which the field receives at the end of the season when the groundnut crop has to be gathered. The early season groundnuts are sown either in the early or late rains; in the former case, the crop is followed by horsegram or late season jola. If sown in the latter rains, then it follows early season or kar ragi or jola. Groundnuts are grown generally pure but the practice of taking a mixed crop is also coming in, especially as the groundnut is a low growing crop and can therefore be grown

The erect type of groundnut, showing how the groundnuts are borne in a bunch at the base of the plant. [Mys. Agri. Dept.

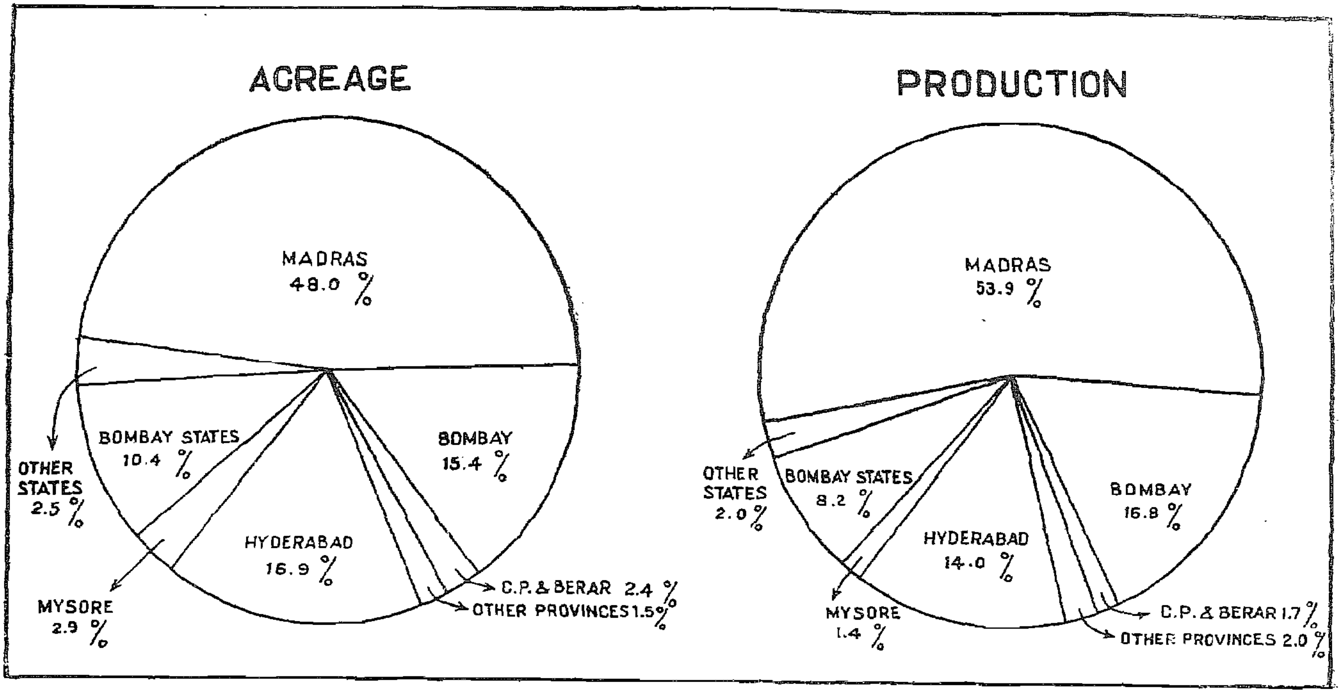


Chart showing the share of the Provinces and States in the acreage and production of Groundnuts in India. (Average)

[From the Report on *the Marketing of Groundnuts.*

as a ground or low crop under tall growing crops like jola, castor, 'sajje,' or 'togare.' In fact it is only these crops that are grown as mixed crops with groundnuts. Even cotton is beginning to be grown in this way, especially the early sown variety—the Dharwar American—in fields with the short duration erect varieties of the groundnut. Irrigated groundnuts are raised largely in rotation with rice, but under garden cultivation one or more of several short season crops like maize, potatoes, or vegetables are grown in rotation.

Cultivation.—Fields are prepared by ploughing several times and cultivating and harrowing to obtain a clean seed bed and a good tilth for the groundnut crop. In tracts of early rainfall on fields ploughed once or twice already after the previous harvest early sowing of groundnut is possible and a short duration variety is sown about the beginning or middle of May. Elsewhere sowings are possible only a little later; but even here if early rains are received and sowing in the month of May is possible, then a short duration variety is likewise sown. As a complete preparation of the soil is not possible so early in these tracts, only the late maturing or long duration varieties are sown about the end of June or the middle of July, the sowings not being possible until the end of this month. Still later sowings are made towards the end of August or the beginning of September, usually after a crop of 'kar' ragi or other early sown crop has been harvested or in between a tall growing crop like castor which may be about a month or six weeks old already. The crop is sown in the Mysore State almost invariably in rows, either in plough furrows in which the seeds are dropped by the hand or through the one-furrow seed drill, the 'sadde'. In the black cotton soil tracts special seed-drills are used which sow two or four rows of groundnuts. The distance between the rows is about 12 inches in the case of the creeping varieties and about nine inches in the case of the erect varieties. In the case of the latter, the closer the rows up to about six inches and the closer the plants in the rows up to four inches, the higher the yield. The closer rows have however the disadvantage that the interculturing of the crop with the usual toothed or bladed harrows becomes rather difficult; but if this can be carefully managed, then this will be the best spacing; otherwise the nine-inch spacing will have to be adopted. Seed is covered by ploughing an adjacent furrow or with the light bladed harrow. In parts of the black cotton soil tracts, notably round Davangere in the Mysore State, the use of artificial manures for groundnuts has become popular. A mixture of one cwt. of sulphate of ammonia and one cwt. of superphosphate per acre are drilled into the furrows at sowing time along with the seeds, the manure being drilled in the one-furrow seed-drill or 'sadde'. Groundnuts respond well to such manuring and heavier doses can be used with advantage if it were not that insufficient rainfall may make it infructuous or possibly even

harmful. Where it is grown under irrigation, higher doses may safely be applied with advantage.

Seed for sowing is obtained from sound pods which have not suffered from damp or mouldiness and have been well dried and stored. The shelling of the seed is done by hand and no machine-shelled seed is sown. The former is very slow and laborious but gives fresh and undamaged seed. Machine-shelling generally breaks and bruises the seeds and further is seldom fresh and the germination becomes very patchy, when the seeds are sown; if, however, freshness can be guaranteed, then the other disadvantage of broken seeds can be allowed for by increasing the seed rate. The hand-shelling is certainly a very tedious process, requires a large number of coolies, and becomes almost impossible where large areas have to be sown. The seed required for an acre of the erect variety is about 80 lbs. of shelled nuts which will correspond to about 120 to 140 lbs. of unshelled seed. For the spreading varieties, about 40 to 50 lbs. of shelled seed will be enough.

In a good moist seed bed, the seeds germinate quickly and the braids are visible above ground in six days or a week. In about three weeks the crop is intercultured with the toothed or bladed harrows and if the crop appears too thick, the toothed harrows are worked once across the field also. If the varieties had been sown by broadcasting or if the field had not been thoroughly prepared, then there is a good deal of hand-weeding to be done, which has to be attended to at least once. In the erect varieties flowering begins in sixty days and the bulk of the flowering is completed in a fortnight; further irregular flowering goes on sometime longer but these later flowers do not mature seed properly. The flowers are borne on stalks close to the base of the plant and on fertilisation bend down and penetrate in the soil where the pod grows and matures. In 100 days the crop is ready for harvest; a trial is however made by pulling out some plants here and there and if the greater bulk of the pods are ripe, then the whole crop is harvested. Harvesting consists in pulling the whole plant up by the roots, which is rather easy in these varieties, especially if there should be a shower of rain about the time, which is usual; otherwise the small weeding hooks are also used to help in the pulling up of the plants. The pods are then separated from the plants only by the hand, either on the field itself or leisurely at home whither the whole crop is carted. In some villages, notably in Chintamani and Kolar Taluks, Mysore State, a small tool is used for this purpose; the head of a small iron rake with the teeth set very close is fixed firmly in the ground with the teeth pointing upwards and the bunch of plants with their pods is beaten and drawn across the rake, when the pods are combed out quite neatly. This makes the work somewhat quicker and less laborious. As there is generally some rain about this time, the pods are often wet; they have to be spread

out in the sun when there is a break or at least indoors to dry to some extent; otherwise the nuts may heat up in the heap and deteriorate. At the earliest opportunity also, they should be dried thoroughly in the sun, before being sent to market or stored. A certain amount of cleaning of the produce from adhering earth by both rubbing and putting through coarse sieves will also have to be done before marketing.

The groundnut haulms or leafy remains of the plant are stacked in the fields or near the homes and after the other crops of the year are also harvested and threshed, they are put into the straw stacks in alternate layers with cereal straws. These haulms and leaves, if exposed to the rain quickly blacken and decompose and are therefore protected, when they are to be used for fodder, by thus stacking them inside the straw stacks. They form a nutritious fodder and have the following composition :—

Proteids	Fats	Carbohydrates	Crude fibre	Ask
11·75	1·8	46·95	22·1	17·0

The creeping varieties of the groundnut are sown in June-July and become ready for harvest about the month of December. The crop covers the whole ground and pods are borne all along the creeping stems and the whole field has therefore to be dug for removing the pods. The fields are either dug or are ploughed to bring up the pods to the surface where they can be separated from the haulms. Even in the best of times this is a difficult and expensive operation and it is at least one reason which prevents a grower from putting down a larger area under it. The ground becomes very hard by this time and if no stray showers are received, the ploughing or digging becomes very difficult. Sometimes the stone roller is worked on the field under these circumstances and this loosens the surface to a certain extent, making the ploughing or digging a little easier. In exceptional cases fields may even have to be abandoned on account of this difficulty, especially when the price of groundnuts is low. Potato-digging ploughs, not too-heavy to be drawn by a pair of good bullocks, have been tried but when the ground is too hard for even the country ploughs, this implement becomes out of the question. Even when the ground is soft enough for its being used, considerable quantities of the nuts are left in the ground without being brought up to the surface, necessitating a good deal of hand-picking. In the black cotton soil tracts a harrow called the 'Sangli kunte" in which the blade works at a sharp angle going almost vertically into the ground is used for harvesting the nuts but on the hard red soil surface the implement is not satisfactory. In the large scale farming of the U. S. A, large potato-diggers of the elevator type are used for harvesting the nuts but even there considerable nuts are left in the ground; this, however, is not considered a loss in their systems of large scale farming. Much

of the nuts remaining in the ground moreover is turned to good use by letting pigs forage for the nuts and feed on them.

Where groundnuts are grown under irrigation, the difficuty in harvesting does not arise. The ground is either soft enough for easy digging or an irrigation is specially given for the purpose. In some villages the haulms are cut and removed and then the field is flooded and ploughed; this brings up the pods many of which even float in the water. Picking is of course very easy; the pods are however wet and have to be dried thoroughly before being sent to market, and such drying takes several days and even then is not complete. A good deal of the groundnut crop of the east coast districts of Madras is raised under irrigation and this practice of flooding the field to gather the crop partly accounts for the complaints regarding the alleged watering of groundnuts as one of the malpractices in this trade.

Yield.—The yields of groundnuts vary very much according as the variety is a short duration one or a long duration one and according as it is grown as a dry crop or as an irrigated crop. The short duration varieties under dry cultivation give on an average about 800 lbs. of unhusked pods per acre with very high yields going up to 1,500 lbs. The long duration varieties yield under dry cultivation from 1,000 lbs. as an average to 1,700 lbs. as a very good yield. Under irrigation the latter may yield up to 2,000 lbs. per acre. All the weights refer to unhusked pods. The weight of a Mysore seer of pods is equal to 1 lb. in the Spanish variety, to about 12 oz. in the Valencia variety and 14·4 oz. in H. G. I. variety. One hundred seers of pods weigh approximately 86 lbs. and 100 seers of the husked seeds will weigh about 194 lbs. The pods yield from 70 to 90 per cent of their weight of shelled seeds, depending upon the variety.

Botany and varieties.—The groundnut belongs to the natural order Leguminoseæ and the sub-order Papilionaceæ. It is a low growing, spreading or prostrate herbaceous annual profusely branching and covering the ground over an area of 2 to 3 feet in diameter. It has a tap root 8 to 10 inches long and many adventitious roots which spring from near the base of the plant and enter the soil. Some varieties have an erect habit of growth and attain a height of about one foot. Others partake of both habits of growth and are erect mainly, with a few stems which are prostrate. Root-nodules are conspicuously and profusely developed on the main root and lateral roots. The leaves are compound with two pairs of opposite leaflets, ovate in shape about an inch long and ½ inch in width, dark or light green in colour on the upper surface and whitish on the lower. The flowers are yellow in colour and are borne in the axils singly or in clusters of two to four. The stamens are monadelphous and are eight or ten in number. The ovary is superior at first. The flower is self-fertilised, both stigma and pollen maturing at the same time. After fertilisation the base of the ovary elongates into a long stalk and

pushes the developing ovary into the soil where it grows and matures into the nut. The pods are 1 to 3 inches in length, cylindrical and reticulated and slightly swollen over the seeds. The seeds are two to four in number and have pale pink to dark brown papery seed coats.

There are a number of varieties in groundnuts. They may be broadly distinguished as erect and spreading (also called 'runner') varieties. The erect varieties are also called 'bunch' types, as the nuts are borne in a bunch close to the base of the plants, while in the 'runner' varieties they lie spread out. The erect types are of short duration and mature in three months or 100 days and the 'runner' varieties are of long duration and take about five to seven months to mature. Differences are noticed in the size and shape of the pods, in the number of seeds in the pods and in their size and colour. The seeds also differ in their oil content. The old Mysore local variety called 'Natu kayi' belongs to the 'runner' class. It has light green leaves with hairy stems which are slightly tinged violet. Its characteristic feature is the shape and size of its pods, which are thin and long, have three to four seeds, small and somewhat wrinkled in shape. The seeds have a lower oil content than the seeds of other varieties and are fancied for being roasted and eaten. The variety is now grown only to a very limited extent and has been displaced by foreign introduced varieties. The most common South Indian variety now under cultivation goes by the name of Mauritius groundnuts which is also referred to as "Coromandal." It is a spreading long duration type, grows vigorously and gives a good yield. The seeds have a high oil content. The pods are small and contain two or three seeds, of medium size and brown in colour. It is a variety which is grown most extensively not only in India but in many parts of the world also, notably in Africa. Many new varieties continue to be introduced and tried, and a promising new one appears to be the variety called 'Saloum' from West Africa, which has been found to yield in Madras quite 25 per cent more than the 'Mauritius.'

In addition to the above two spreading varieties, erect varieties of two kinds are largely grown in Mysore and elsewhere in India. These are (1) the Spanish, also referred to as "Peanuts" or "Natal" and (2) the Small Japan, also called "Red Natal." The 'Small Japan' is a vigorous plant growing about a foot in height. The leaves have a yellowish tinge in the green. The pods are short and almost rounded and the shell thick. The pods contain only two seeds and sometimes only one, which are smooth, round and deep brown or red in colour. The seeds have a high oil content. The 'Spanish' resembles the 'Small Japan' in growth but pods and seeds are smaller, and the seeds are pink or rose coloured in marked contrast with the dark red of the 'Small Japan.' Both varieties are short duration crops maturing in about 100 days. A peculiarity of the erect types is the lack

of dormancy in the seeds. The first formed pods may sprout before harvest if this is delayed and if the soil is sufficiently moist. The spreading varieties are free from this drawback.

On a comparatively small scale there are also grown many foreign varieties, such as, 'Virginia bunch,' 'Valencia,' 'Virginia runner,' 'Big Japan' (also called 'Bold') and so on. The first two are erect types and the others are spreading types. All are characterised by large pods and seeds. A good variety evolved in Mysore is the H. G. 1 which though an erect type, gives a larger yield.

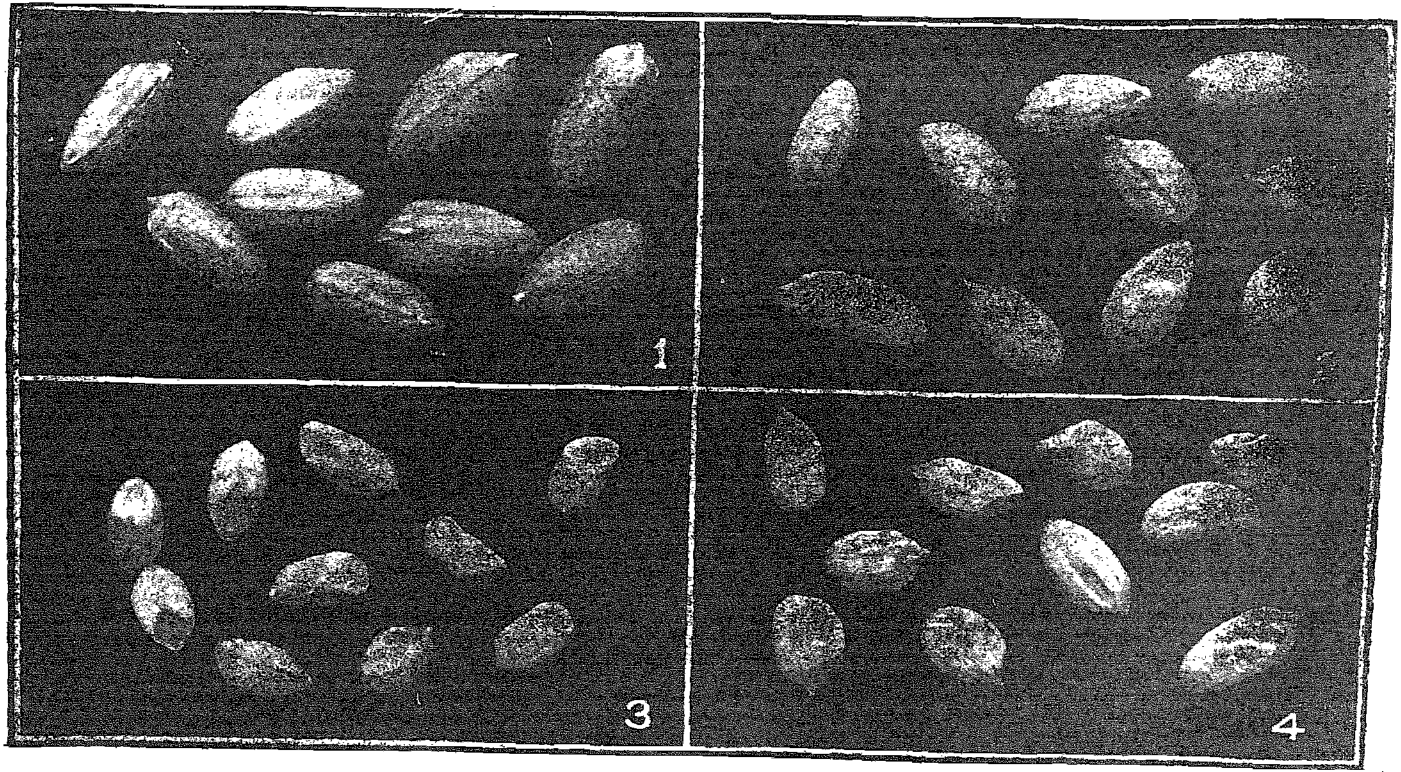
Pests and diseases.—The hairy caterpillar—*Amsacta albistriga*—which has been described as attacking ragi, jola and many other crops, attacks the young groundnut crop also and completely defoliates it. If the attack is very bad, it may be even necessary to re-sow the crop. The remedy consists in hand-picking the moths when they emerge and are seen on the crop. As already explained, this is not a difficult matter and is found very effective. This is probably the most serious insect pest on the crop in Mysore.

The 'Surul puchi' or leaf roller—*Stomopteryx nerteria, Meyr.*—causes much damage in Madras. The pest is the larva of a small moth, which webs several leaves together and feeds on them. After feeding for three weeks the larvæ pupate inside these rolls of leaf and during these three weeks the destruction of leaves wrought is very great. The moth emerges in four days, lays eggs on the leaves, from which in another three or four days a second generation of larvæ hatch out; these burrow into the leaves and later on commence to bind the leaves together into small rolls again. No satisfactory control measure has been worked out.

The most serious disease of groundnuts is what is known as 'Tikka' disease.—*Cercospora personata* (B. and C.) Ellis—Small yellowish spots are formed at first on the diseased leaves, which become larger and then run into each other, forming large patches of yellowish brown areas. These affected leaves then drop off and the plants are so weakened by the loss of leaves that pods do not form at all or do not develop into the normal size, No control measures are known and the remedy appears to lie only in evolving resistant types.

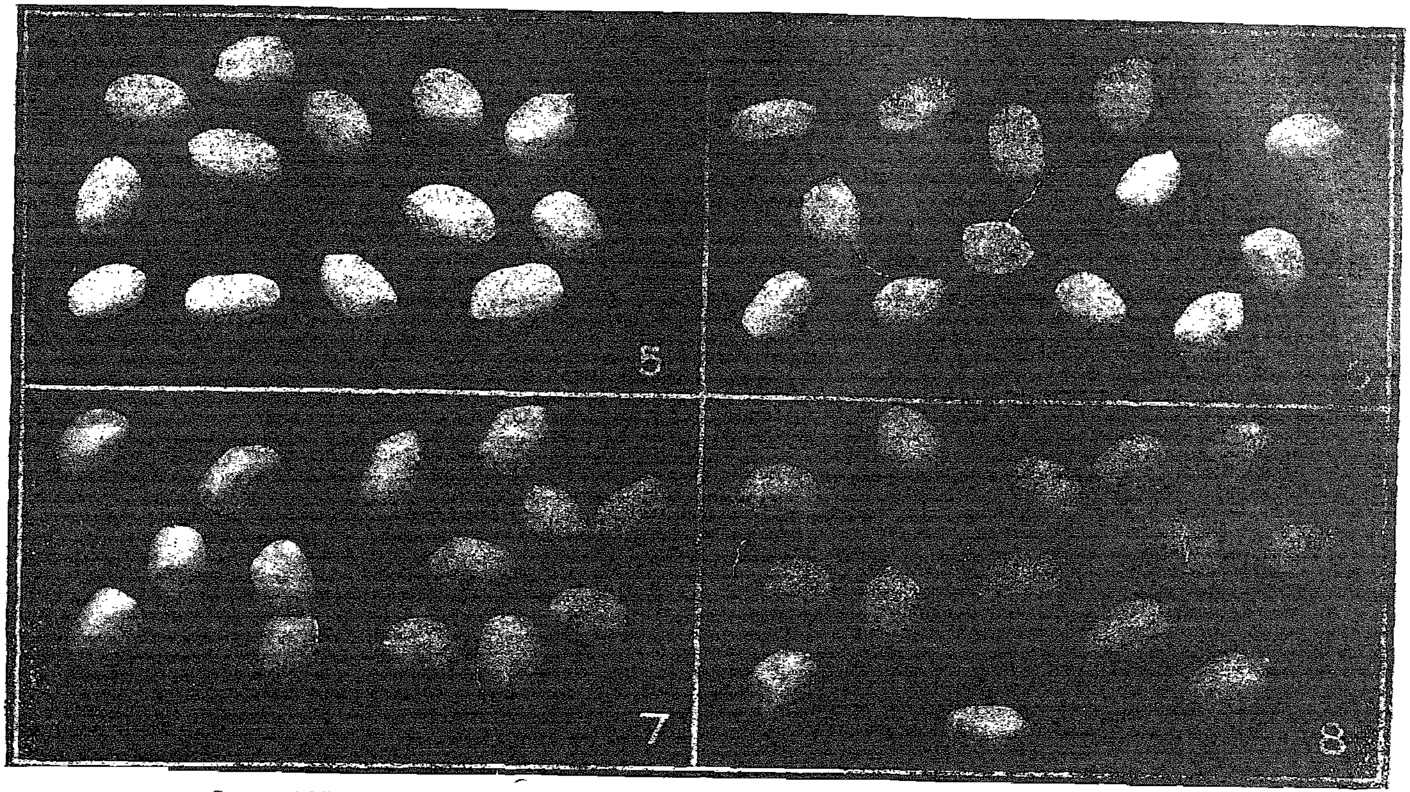
Another disease, which is regarded as a virus disease, causes a dwarfing of the plants and a crowding or the shortening of the leaves, giving them a rosette-like appearance, and producing moreover a yellow spotting of the leaves. Still another disease noticed on groundnuts is a kind of 'mosaic' disease which is said to be destructive in South Africa. Both diseases, though they have been observed in India, have not so far become serious.

Other enemies.—A great deal of damage to groundnuts is caused by the ravage of wild pigs which make the cultivation of the crop in certain tracts impossible. Watching at night and



Commercial Varieties of Groundnut Kernels.—1. Kathiawad Bold, 2. Bold, 3. Coromandel, Karad

[From the Report on the Marketing of Groundnuts.



Commercial Varieties of Groundnut Kernels.—5. Khandesh, 6. Khandesh quality, 7. Peanuts, 8. Natal Red.

[From the Report on the Marketing of Groundnuts.

exploding a small charge of gunpowder to scare them away are the methods resorted to. Pig-proof fencing has been introduced and put-up co-operatively by villagers in certain parts of the Bombay malnad but ordinarily this is too expensive to be thought of. Poison baits and percussion charges hidden inside baits made of cooked ragi or rice are also used. When the crop is maturing, crows commit a lot of havoc especially on light sandy soils into which they can easily peck. The crop has to be watched against this pest.

Chemistry and uses.—Groundnuts are cultivated principally as an oilseed but considerable quantities are used directly for human consumption like any of the ordinary pulses. The nuts are first shelled and then used either toasted or fried and salted or boiled, and both by themselves and mixed with a variety of vegetables. Like other edible nuts, such as walnuts, almonds or hazel nuts, groundnuts enter into various forms of confectionery, toffees, etc. Freshly fried and salted and along with popped corn or maize, it is a favourite delicacy sold at all street corners in American cities. In India toasted groundnuts eaten with some jaggery form a cheap and sustaining food.

It is, however, as a source of oil that groundnuts find their largest use. The oil of the groundnut is a non-drying edible oil. Decolorised, deodorised and hydrogenated, the oil enters largely into the manufacture of 'margarine' in Europe and America. In India it is used as a cooking oil for frying various articles in the same way as gingelli or cocoanut oil; like these again, it is used as an unguent. It is also largely used for adulterating gingelli oil. Mixed with other edible oils and by itself it is subjected to hydrogenation and the resulting solid product is sold as vegetable ghee or used to adulterate butter and ghee. The quality of the oil is given by the following constants:—

Specific gravity at 15°C.	...	0·925
Saponification Number	...	185·6 to 196
Iodine Value	...	84 to 105
Reichert Miesel Value	...	0·5
Refractive Index	...	1.47.

The largest use for the oil especially of the lower grades is as soap stocks for the manufacture of soaps. The oil is extracted by pressure in rotary or hydraulic mills or in the 'Anderson Expeller.' Oil is also extracted by means of chemical solvents like petrol, and both oil and petrol are later separated, the latter to be used over and over again.

The oil-cake obtained after the extraction of the oil is a valuable cattle food and a manure. The oil-cake obtained by comparatively low pressures as in the country oil-mills contains considerable oil unexpressed, while the other mechanical appliances exerting more pressure also leave more or less oil unexpressed though very much less than with the country mills. The

cake (or meal) left after chemical extraction is practically free from oil. This meal is not used as a cattle food on account of the smell from the solvent. The percentage of nitrogen (or proteids) in the cake varies inversely as the oil content, so that the greater the oil left in the cake the less is its nitrogen content and *vice versa*. The feeding value of bazaar cake is given by the following composition :—

Oil	Albuminiods	Carbohydrates	Fibre
13·4	50·0	22·5	2·75

The kernels (of shelled nuts) of different varieties of groundnuts differ in the percentage of oil they contain. Thus the oil contents of the three main varieties Mauritius, Small Japan and Spanish are as shown below :—

Mauritius 46·4 Small Japan 50·2 Spanish 46·4

The proportion of shell to kernel in the different varieties also differ and range from 70 to 75 of kernels to 30 to 25 of shells, both by weight.

The chemical composition of groundnuts indicating their value as a food is as below :—

Water	Albuminoids	Oil	Carbohydrates	Fibre	Ash
7·5	24·5	50	11·7	4·5	1·8
4·7	29·1	49·8	13·2	1·6	2·1
7·9	26·7	40.1	20·3	3·1	1·9

Groundnut cake is extensively used for manurial purposes both by itself and in mixtures. It is richer in nitrogen than other oil-cakes and it is also the most quick acting among them. The plant food percentages in average samples are asbelow :—

Nitrogen	Phosphoric acid (P_2O_5)	Potash (K_2O)
7·6	2·0	1·5

Groundnuts are a favourite crop principally because the produce can be sold and converted into money quickly. In the case of the early season crop, the money return is received in the crop year itself and in the case of the long duration varieties much sooner than with the grain or pulse crops of the year. Growers sell their groundnuts in the unshelled condition and in marketing centres where there are hulling establishments. For want of storage accommodation in the homes, the crop is sold immediately after harvest. Carting to market centres is a heavy item of expenditure and marketing charges and practices work much to the grower's detriment; nevertheless, as the returns are quick, these are all put up with uncomplainingly.

Production and trade.—The total area under groundnuts in India in 1938-39 was 8½ million acres. The cultivation has increased enormously during the last twenty years as the acreage

under the crop was only two million acres in the year 1914. The Indian acreage at the present time amounts to 36 per cent of the total world's acreage. The main producing tracts in India and the acreage under cultivation in each are as below :—

Madras	3,820,000
Bombay	2,384,000
Hyderabad State	1,686,000
Central Provinces and Berar ...	226,000
Mysore State	221,000
United Provinces	159,000
Orissa	20,000

Groundnuts form a most important export produce from India. Large quantities of seed, oil and oilcake are exported mostly to the United Kingdom, France and Germany. The quantities exported in the year 1939-40 were as below :—

Groundnut seeds—548,564 tons valued at about Rs. 7·2 crores.

Groundnut oil—about 4 million gallons valued at Rs. 51 lakhs.

Groundnut oilcake—232,095 tons valued at Rs. 21 lakhs.

III. CASTOR (Ricinus communis).

VERNACULAR NAMES FOR CASTOR:—*Kannada*—HARALU; *Tamil*—AMANAKKU, KOTTAI MUTHU; *Telugu*—AMUDALU; *Malayalam*—AVANAKKU; *Hindustani*—AREND.

Distribution.—Among the oil seeds of India, castor occupies the first place in regard to the quantity of seed and oil exported. India is also the most important source of the world's supply of castor oil. Believed variously to have had its origin in India and in North Africa, the castor plant is now grown in many parts of the world, such as the United States of America, Queensland, Egypt, the Sudan, and many parts of East and Central Africa, in Southern Europe and in many countries in Asia including Arabia and Iraq, China and Japan. It can be seen growing in elevations of up to 5,000 feet and even 7,000 feet; provided frost does not set in before it matures, it can be grown in all countries where maize can be grown. It can be grown in dry arid climates and can stand very heavy rains and floods.

In India its cultivation is mainly confined to the Hyderabad State, Madras and Mysore which grow about 781,000, 264,000 and 103,000 acres, respectively.

Soils.—Castor is grown generally on the deep red loams, both sandy and clayey, on good light alluvial loams, and even on rough gravelly uplands. A coarse open texture of the soil is favoured and the deep black cotton soils are not usually put down to castor. It can, however, be grown on the somewhat clayey

soils of rice fields, but even here a considerable admixture of sand rendering the soil well drained is necessary. On these soils castor is grown as a garden crop, with irrigation generally, as a shade crop or on field margins in fields of turmeric, ginger or sugarcane.

Rotation.—The castor crop is grown almost entirely as a dry crop, and is rotated with the ordinary dryland crops. It occupies the ground for the whole crop season and therefore forms the sole crop of the year although many other crops can be and are grown as mixed crops. Castor takes from five to eight months to finish a crop in the dryland cultivation but there are varieties which either grow as perennials or at least keep growing for more than one season. Castor is rotated with the main season ragi, with its mixed crop of 'avare' or 'togare', with jola and its mixed crop of 'togare' with 'haraka', 'sajje' or with groundnuts, Dharwar American cotton, dryland chillies, tobacco or horsegram. The castor crop can be generally removed from the field only about the month of March and will therefore not allow of the field being prepared and put down to early crops followed by a late rain crop in the same year. It is usually therefore followed by another main season or late season crop. As mixed crops in castor, the following are grown in different parts of Mysore, *viz.*, various pulses like 'avare', 'togare' and cowpeas, dryland chillies, gingelli, horsegram and short season groundnuts. With the pulses as a mixed crop a row of castor alternates with a row of one or other of those named above, but in the rows of the pulse crop also castor plants are sown somewhat sparsely, so that one row of pure castor alternates with a row of a pulse crop mixed with castor. Castor sown with chillies comes in rows about six to eight feet apart with four rows of chillies which are planted in rows about $1\frac{1}{2}$ feet apart; short season groundnuts or gingelli are likewise sown between castor rows which are made from three to six apart depending upon the importance attached to the respective crops by the grower. The horsegram is sown late in the season after the interculturing for the castor is finished. The horsegram covers the ground completely as it is sown between the castor rows both lengthwise and crosswise.

Cultivation.—The field for castor is generally well prepared as for ragi, the ploughing commences after good soaking rains are received and is repeated after each good rain; the clods are broken and the weeds dragged by the bladed harrows and the seed bed got ready for sowing in the rains of July. A good deal of sowing is postponed until the grain crop sowing can be finished and the castor in that case is sown even until September and on poorly prepared ground. In this latter case furrows are hurriedly ploughed at distances of three feet from each other both lengthwise and crosswise and in the intersections of the furrows the seeds are sown. The interspaces are ploughed later on when the pressure of work becomes less.

Normally however castor is sown after the seed bed is well prepared. When grown pure it is sown in rows three feet apart and at distances of two feet in the rows or at distances of three feet each way. Plough furrows are ploughed at these distances both along the length and across the fields and the seeds are dibbled by hand at the intersections of the furrows two or three seeds being put into each hole. Where mixed crops have to be grown the furrows for the castor are ploughed at varying distances according to the needs and wishes of the grower, and interspaces are sown with the mixed crop either in a three or six-tyned drill. The seed is covered by a light bladed harrow or a wooden toothed harrow. About three weeks after the plants come up, the field is intercultured ; the interculturing is either by ploughing or by working a couple of bladed hoes both along the length and the breadth of the field in the interspaces, when castor is sown pure or with bladed harrows of appropriate widths when mixed crops are sown. These hoeings earth up the rows of the castor and of the intercrops in addition to removing the weeds. The early sown crop begins to bear inflorescences from about the end of October and the ripe fruits are ready to pick from the end of November. The fruit bunches have to be picked at the proper stage, usually some considerable time before they begin to dry while they still retain their green colour. The fruits in the bunches mature at short intervals and dry fruits split and scatter the seeds. To avoid this risk the bunches are gathered before any sign of drying is to be seen. Some plants bear only one bunch, others bear two or more. The gathering of the pods goes on almost until the end of February of the following year. The pods are heaped up until the skin blackens and dries, and are then spread out in the sun to dry. The seeds are beaten out with sticks, winnowed and screened to remove the husks, dry skins and adhering earth.

Yields.—When grown as a pure crop, yields up to 900 lbs., of seed per acre are obtained from well grown crops and 400 to 500 lbs., from average crops. Even poor crops yield 200 to 300 lbs., per acre. A 'palla' or 100 seers (Mysore) of the seeds weighs 162·5 lbs., or a seer weighs about 1·6 lbs. The volume weight however varies materially according to variety.

Botany and varieties.—The castor oil plant—*Ricinus communis*—belongs to the natural order Euphorbiaceae, which comprises a large number of tropical herbs, shrubs and trees. There are many varieties of castor which are annual and others which are perennial. The stems are hollow and are either straight with little branching or are many-branched. Varieties greatly differ in their height; the ordinary field varieties range from six to ten feet, others grow up to 15 or 20 feet, almost like small trees and in one case the remarkable height of 30 feet is also reported. The leaves have long stalks, are palmate, glaucous with serrate

margins. The stems including leaf stalks are differently coloured in the different varieties, the colours falling into two distinct classes, *viz.*, light purple and green, in both of which some have a white bloom on them and others are devoid of it. One variety is indeed highly ornamental with stems and inflorescences deep red in colour.

The inflorescences carry both male and female flowers and are panicled racemes which start from the terminal buds of the main growing shoot of the stem and of the branches The male flowers are found at the base of the inflorescence and the female flowers higher up. The fruits are three—celled, three—sided capsules almost round in shape about the size of a marble, and are either smooth skinned or covered with short spines. These two different kinds of fruit are to be found in both the main types, the green and purple stemmed. When quite ripe the capsules in some varieties burst and scatter the seeds, while in others they are non-dehiscent and have to be dried and beaten to separate the seeds. The seeds are oval flattish to rounded and the seed coat is hard and shiny and coloured variously from brown to black and marbled or speckled. Varieties differ in the size of the seeds, in colour and the oil content. The seeds of the small seeded varieties are about $\frac{3}{16}$ inch across and the seeds of the large seeded varieties may be $\frac{1}{2}$ or $\frac{7}{8}$ inch across. In between the two are many intermediate types. The number of seeds per lb. has been found to range from 448 to 5,376! The oil content also varies from 48 per cent up to 56 per cent in the different varieties. The annual varieties differ in their period of maturity which varies from five months to eight months. The annual varieties grown on dryland are usually small and medium seeded, while the garden and ornamental varieties have large seeds. The varieties with very large seeds are usually rather low in their oil content. The varieties which are grown under garden cultivation and on the margins of the sugarcane fields are rather high in their oil content as compared with those grown in dry fields. They also vary in the number and length of the inflorescences, the latter sometimes measuring $2\frac{1}{2}$ feet in length. The small seeded variety gives oil which is generally esteemed for medicinal preparations. Many of the abovementioned characters of the seeds as colour and size are to be found in the seeds of both the annual and the perennial or semi-perennial varieties.

The castor seed consists of 20 per cent of husk or shell and 80 per cent of the soft kernel which contains the oil. The unshelled or 'undecorticated' seeds contain from 40 to 53 per cent of oil while the kernel contains 58 to 66 per cent of oil. The small seeded varieties contain about 7 to 8 per cent more oil than the large seeded varieties in their seeds. Much variation in the oil content of one and the same variety is caused by the stage at which the seeds are harvested. The difference between dead ripe

seeds and those harvested earlier may amount to as much as 9·5 per cent; in fact this factor of maturity gives rise to a greater difference in the oil content than varietial characteristics.

Pests and diseases.—The castor plant is subject to a number of insect pests, which comprise leaf eating insects, shoot and pod boring insects, and those which suck the sap. There are several kinds of insects under each of these groups, but only a few of them that can be considered as serious pests. Among the leaf eating insects the most important and a very common and serious pest is the castor semi-looper, *Achoea janata, L.* These grubs breed in enormous numbers and feed voraciously on the leaves of the castor. The attack usually begins on the young crop itself which is often so badly defoliated that the crop has to be ploughed up. When grown up plants are attacked the damage is equally great and the plants are completely stripped and form either no flowers at all or only diminutive ones which come to nothing. The caterpillars hatch out from eggs laid singly by the female moth on the underside of the leaves. A single moth can lay some 400 eggs and these are laid all over the crop as not more than five or six eggs are laid on a single leaf. The caterpillars feed voraciously and grow into the characteristic hump-backed smooth-bodied grubs, and pupate in the ground or on the plant itself. The moth emerges in ten days or a fortnight. A generation takes only about a month and some two or three broods therefore appear in the season and the number of eggs laid becomes prodigious. The pest is however subject to the attack of parasitic wasps and the caterpillars are eaten by birds both of which agencies keep down the numbers a great deal. In the attacked fields crows and other birds descend in swarms and gorge themselves on the grubs, both morning and evening. Unfortunately the birds seem to be attracted only when the loopers are somewhat grown and have therefore done considerable damage. One remedy based upon this circumstance is to attract birds into the fields by scattering balls of cooked rice or ragi from which they may pass on to the grubs themselves even when these are not fully grown.

The spraying of the plant at an early stage with a solution of lead arsenite or Paris green is also effective, but rather expensive. The life history has been fully studied and as the larvae pupate under the castor plants it is advised that the castor fields should be well ploughed after harvest to expose and kill the pupae, so that they may not form the starting point for the emergence of the insects in the following year.

Considerable damage is done to the pods or capsules while on the plant by a pod-boring insect—the *Dichocrocis puncti-feralis G.* This is a pinkish brown caterpillar which bores not only into the young and ripening capsules but also into the shoots especially where they spring from the main stem. It is the same boring insect which attacks the shoots of turmeric,

ginger and cardamoms. Though the pest is fairly serious, there are *no effective* remedies known. The cutting off and burning of the affected shoots and capsules will however prevent the spreading of the pest.

Though several bugs and sap sucking insects are sometimes found on the castor plant, none of them cause any serious damage.

Diseases.—The castor plant is subject to the attacks of a number of fungus and other diseases. These are (1) a rust disease—*Melampsorella ricini*—which appears as bright coloured spots covering the whole leaf, (2) a leaf spot disease—*Cercosporina ricinella*—which appears on the leaf as irregular spots with a greyish centre and a brown outer ring, (3) a mildew—*Oidium sp*—on the leaves, (4) a stump rot—*Diplodia ricinella* and lastly a bacterial wilt—identified as the bacterial wilt attacking the potato crop and other solanaceous plants. The castor crop suffers from these only in a minor degree and the damage is seldom serious.

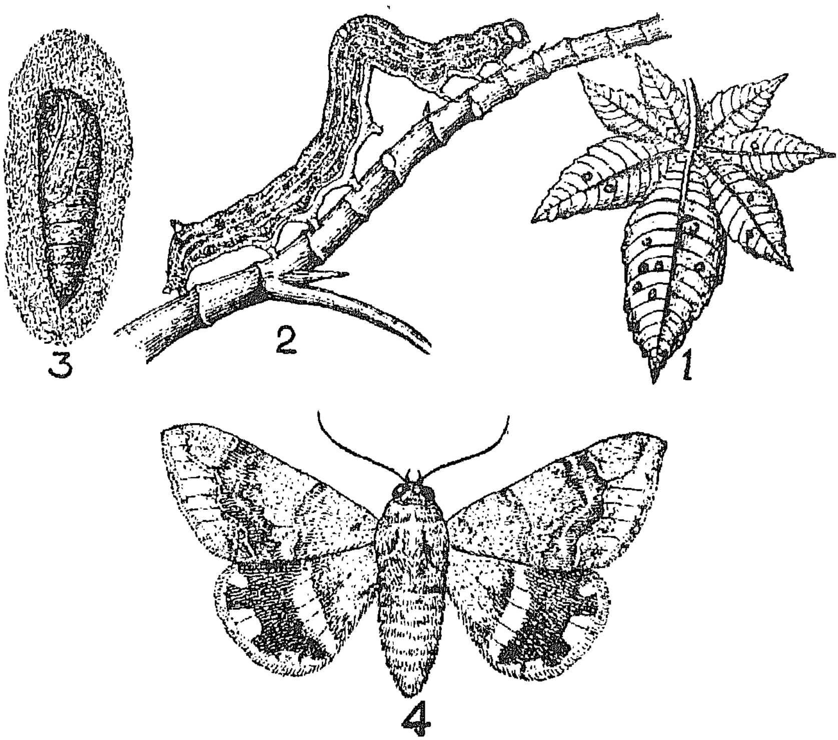
Chemistry and uses.—Castor oil is a non-drying oil, with the following physical and chemical constants :—

Specific gravity at 14·5 ° C	...	0·959 to 0·969
Refractive index at 40 ° C	...	1·4679 to 1·4723
Viscosity at 100 ° F	...	1160 to 1190
Saponification number	...	175 to 185
Iodine number	...	82 to 90
Reichert—Meissel number	...	1·0 to 2·0

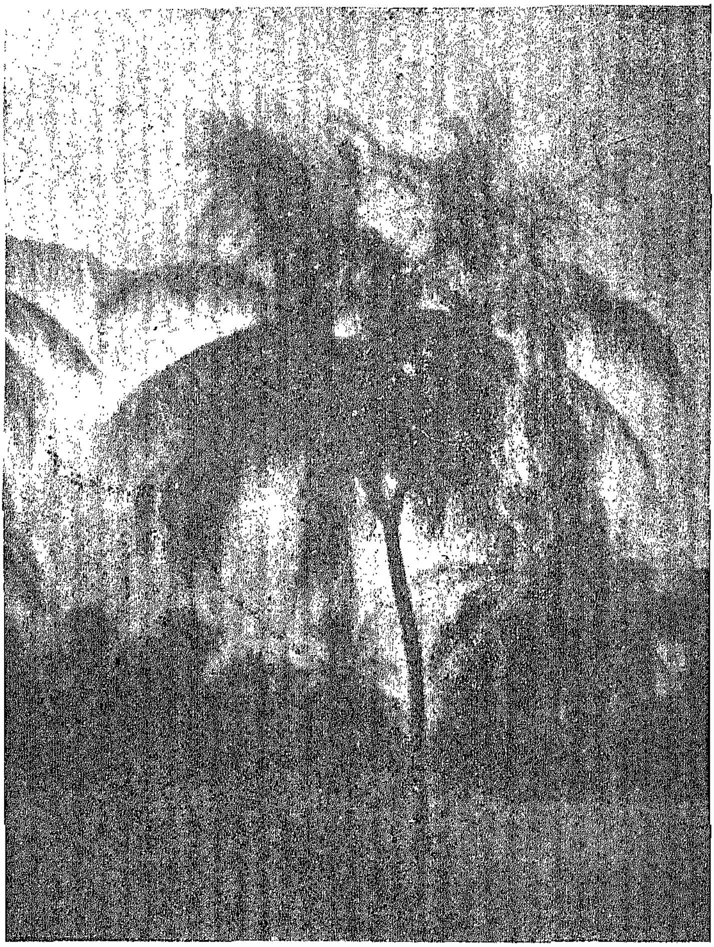
The oil does not become rancid; but if the decorticated kernels are stored for any length of time the lipase in the seeds acts and liberates the free fatty acids. If these seeds are used for making 'cold drawn' oil, then the fatty acids will pass into the oil and give rise to rancidity.

The castor oil cake is a valuable fertiliser; but owing to the presence of the poison 'ricin' it is unfit for cattle feed. The oil cake will vary in composition according as it is prepared from 'decorticated' or 'undecorticated' seed. The former will contain 6 to 7 per cent nitrogen and about 2·25 per cent of P_2O_5 while the latter only from 3 to 4 per cent of nitrogen and about 1·8 per cent of P_2O_5.

Castor oil finds a number of uses for domestic, medicinal and industrial purposes. As a purgative with properties which no other drug or specific is said to possess it is a universal medicine. It finds other medicinal uses also. In Indian households, it is used for anointing the head and body; it is used as an illuminant, giving a bright and steady flame and burning much longer than any other vegetable oil. It is used as a lubricant in all moving parts of machinery, and for internal combustion engines especially those used on aeroplanes, it is unsurpassed and is greatly valued. It remains liquid at the low temperatures of the



The Castor Semi-looper.
1. Eggs, 2. Grub, 3. Pupa and 4. Moth.



A two-stemmed cocoanut tree, in which both the stems are equally well-developed, grow normally and bear well; a rarely seen curiosity, the result probably of damage by the rhinoceros beetle.

[Photo by Author.

upper atmosphere and maintains its viscosity at the high temperatures attained in the cylinder of these engines. It is also processed into a material which dissolves in mineral oils and then used as a lubricant. In the dyeing industry, it is used for the preparation of 'Turkey red'. It finds industrial use also in the preparation of a number of special products like artificial leather, linoleums, etc., and in the making of certain transparent soaps.

Castor seeds also contain two special constituents, *viz*, (1) ricin and (2) lipase. The 'ricin' is a blood coagulating poison. It is the presence of this ingredient which makes the castor oil cake unfit for feeding cattle. 'Cold drawn' castor oil is free from ricin. The lipase is a ferment which has the property of splitting up oils into glycerine and the fatty acids and is prepared for industrial uses out of the castor seed.

Castor oil is extracted on a small scale by grinding up the kernels into a fine pulp, stirring it with water and boiling the mixture, when the oil rises to the surface and can be ladled out. On a large scale, the cold drawn oil is prepared by pressing *kernels of selected seeds at a temperature not exceeding 100 °F.* which yields about a third of the total oil content and free from ricin. On an industrial scale, the extraction of the oil is carried out by a variety of processes employing both pressure and chemical solvents and the oil subjected later to considerable purification.

Production and Trade.—The total area under castor in India including the States in 1937-38 was about 1·3 million acres. The largest area is grown in Hyderabad where the crop is grown on about 735,000 acres. The area in Madras, Bombay and Mysore were 250,000, 42,000, and 96,000 acres, respectively.

India ranks as the largest source of the world's supply of castor seeds and castor oil. The export of castor seed and of castor oil in the year 1939-40, were as follows:—Castor seed—40,437 tons valued at Rs. 32 lakhs in round figures and castor oil—1,253,750 gallons valued at Rs. 23 lakhs. In addition castor oil-cake is also exported to a small extent, which amounts to approximately 3,000 tons per year.

IV COCOANUT (Cocos nucifera.)

VERNACULAR NAMES FOR COCOANUT:—*Kannada*-TENGU, *Tamil*-THENNAI, *Telugu*-TENKAI, *Malayalam*-THENNAI, *Hindustani*-NARIAL.

Unlike the oilseeds grown as ordinary annual field crops, the cocoanut is the product of the cocoanut palm which is a perennial tree grown as a permanent garden or plantation crop. The cocoanut palm not only furnishes one of the most important

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of vegetable oils but a number of valuable products the chief among which is coir or cocoanut fibre. In many parts of the world where the palm flourishes it furnishes not only food and drink to the inhabitants but a large number of their domestic needs, for which some part or other of the palm is found useful. The oil and coir were so greatly in demand in the world's markets not many years ago that it was considered one of the most profitable crops to grow being called indeed the 'Consols' of the East, and vast areas were planted up and millions of pounds invested. At the present time there is apparently a large over-production which has led to rather disastrous results.

Distribution.—The cocoanut palm is a typical tropical crop and its cultivation extends throughout the tropics. The palm is also associated with proximity to the sea, and the innumerable islands of the tropical seas are veritable groves of cocoanuts which often grow as the natural vegetation of these islands. Its cultivation is therefore largely restricted to coastal belts of tropical countries. India, Ceylon, Malaya and the Straits Settlements, the whole of the Eastern Archipelago, Java, the Phillipines, Indo-China and Siam, the Pacific Islands of Samoa, New Caledonia, parts of Fiji, the Coastal Belts in Peru, Brazil, the West Indian Islands, the Mauritius, East Africa, Zanzibar and the Seychelles, the island groups of Laccadives, Maldives, Andamans and of the Nicobar are among the most important cocoanut growing countries of the world. The cocoanut palm is one of the most ancient plants known to mankind and its natural home is a much debated subject, some writers placing it in South America and some in the islands of the Eastern Archipelago. In India it has been known and cultivated from the most ancient times being compared to the 'Kalpaka Vriksha' the tree of the Gods which yields and continues everlastingly to yield all one wants.

The cocoanut palm requires a tropical climate. Salt-laden sea breezes are also considered desirable, such as can be secured by proximity to the sea. This however is not an indispensable or even an essential factor, as the cocoanut plantations in the Mysore State demonstrate, these being situated at least a hundred miles inland. In Bengal also cocoanut palms flourish far inland up to a distance of about 150 miles. This distance probably is the limit. The palm flourishes generally on the plains and the coast and the higher altitudes are not suitable. Though this is true to a large extent, the palm is not so strictly confined to the sea level or low altitudes. The plantations in the Mysore plateau grow at elevations of between 2,500 to 3,000 feet above sea level.

Soils suited.—The soils suited to the cocoanut palm are sandy loams, light sandy soils, alluvial soils such as those in the deltas and river valleys in which the soils contain a large proportion of sand. In the sea coast the palms may be seen growing on almost pure sand, provided it is settled firmly so as

to afford a good anchorage to the tree and is not subject to drift. This adaptation of the palm to the soils almost entirely sandy or with a large proportion of sand in them which is thus one of the chief requirements in cocoanut soils is very remarkable. The palm also flourishes on the red loams, on light grey soils, on soils inclined to be alkaline, and even clays of the black cotton soil type, provided they all contain sand, or easily disintegrating grit and gravel, and therefore approximate to sandy soils in respect of openness and drainage. In fact in gardens raised on such clayey soils the carting of sand to the gardens is a regular annual operation. On soils in the typical lateritic tracts such as the Malnads of Mysore, the palms do not flourish, nor in places where the soil is underlaid by rock or stiff clay within about four feet of the surface, even though the cocoanut is not a very deep rooted tree. Where however the soil is mixed with easily crumbling rocks and rock debris, the palm thrives exceedingly well. In the Mysore Government Farm at Babboor the soils contain a large admixture of such rock debris which also contain, or weather into, considerable soluble salts of potash, soda and lime, and the cocoanut plantation on the farm is remarkable for its growth and productivity. In the whole tract where this Farm is situated the soils are mostly of this nature and in many places distinctly of the alkaline type, and the cocoanut palm flourishes exceedingly well under irrigation in these soils. The cocoanut also flourishes in situations where there is underground water within its root range, in fact on the coasts and back waters the trees grow with their roots touching the water and bathed in it. Nevertheless if the land is water-logged with stagnant water the palm becomes sickly and yellow as may be seen where cocoanut trees stand in and among rice fields. In these back water margins and the coast, the ebb and flow of the tide prevents the stagnation. The cocoanut palm also withstands considerable brackishness and salt in the water but the sea water which percolates through the sand to the roots of the palm is to a large extent deprived of the salt in it in this process and the water round the roots is therefore not so salt-laden as it may be thought.

Rainfall and irrigation.—The cocoanut palm requires some 30 inches at least of well distributed rainfall such as obtains about the equatorial regions, where hardly a month passes without one or more good showers of rain. The rainfall of Ceylon and of Zanzibar are good instances of the kind required. Where rainfall is confined to a few months such as in the case of one or other of the two monsoons and the remaining months are dry, then cocoanut gardens have to be irrigated or such cultivation methods followed as will carefully conserve the rainfall in the lower layers of the soil. In South India and the Mysore State cocoanut gardens are largely irrigated. The gardens are established only where irrigation facilities exist, such as under large irrigation tanks and canals or wells. In fact the underground

moisture is really much more important for the cocoanut than even the rainfall. Tracts where a good deal of flood water flows during the rains and thoroughly soaks the soil possess very good cocoanut gardens even though the rainfall is very much below 25 inches, as the soil moisture in those tracts is conserved by proper methods of cultivation. This is the case in many of the cocoanut tracts of Mysore. Many of these tracts are broad shallow valleys which form the drainage lines for the rainfall of the tract. Others lie along the banks of shallow streams which are too small for the monsoon rains and therefore overflow the almost level banks for considerable distances, the water standing for several days and depositing much fertilising silt as well. In the shallow valleys of the first type it is usual to hold up the rain water for some days by erecting low earthen bunds across with a small weir for the surplus, so that water can stand for some days in the garden and saturate the soil to great depths. The soils of such gardens are fertile red loams with enough sand for proper drainage and sufficient clay to absorb and retain moisture. The necessity for ensuring moisture in the ground limits cocoanut gardens to flat or only slightly sloping situations. Terracing of hillsides on very undulating country is sometimes attempted but the growth is not satisfactory in such situations. Throughout South India cocoanut gardens occupy the flat plains in the coastal tracts or, if in inland situations, along only river valleys practically hugging the river on both banks.

Mixed and pure plantations.—Cocoanut plantations are largely pure plantations of cocoanut trees only; but it is usual to a small extent to lay out mixed gardens in which cocoanuts are grown along with other trees like areca, jack, mango, oranges, and so on. Although with the small owner this kind of cropping has advantages especially in reducing risks due to failure of crops or low prices for any particular crop and also in providing him with something like a succession of crops throughout the year, this practice is detrimental to the cocoanut trees. The shade and proximity of the other trees intferes with the normal growth and productivity of the cocoanut trees which grow thin, slant away from large trees and begin to bear much later than otherwise and even after they begin to bear yield only a small number of nuts. The tree roots draw away the moisture from the cocoanut trees, sending out roots which can be traced right into the bole of the cocoanut tree. When a young cocoanut tree not far from a jack tree had to be dug up for being removed to a different situation it was noticed that the roots of the jack tree about the size of a man's forearm had penetrated into the bole of the cocoanut tree; these roots when severed were pouring with sap from the direction of the cocoanut tree. Cocoanut trees in similar situations are found to bear only after they grow tall enough to clear the canopy of the jack or mango trees, that is to say, only several years after trees in the open had begun to bear. The

only vegetation that can be tolerated is something by way of a nurse crop in the young plantation such as plantains for shade and coolness, and the growing of catch crops either of grain or pulses during the first few years of the plantation, though even these may not be always advisable.

Seedlings for planting.—Cocoanut seedlings for planting are of two classes according to the age of the seedlings. They are either in the stage when the seednut remains entire and attached to the growing shoot or when they have passed this stage, the seednut has decayed away and the seedling has established itself on its own root system. In the first case the seedlings are about one year old and in the latter case they are older. If it is decided to plant the older seedlings, usually three-year old seedlings are selected. When required for planting, these older seedlings are lifted from the nursery with the roots undisturbed and with the large ball of adhering earth in which the roots are growing. These are about 18 inches in diameter and for transport are protected by being wrapped in old gunnies or mats tied or stitched over them. The younger seedlings, *i.e.*, those with seedling nuts are easy to transport, and are really preferred for this reason among others, especially where large numbers have to be taken out and planted. These seedlings are believed to make quicker growth and to be more certain; the older seedlings mean a saving in time of about two years although in good soils the younger ones overtake them in growth. The younger seedlings have to be looked after more carefully especially against white ant attacks and over-watering and decay of shoots, both of which lead to the death of the plants. The older seedlings have on the other hand to be guarded against the cocoanut beetle in addition. On the whole the advantage is on the side of planting young seedlings, which in addition cost only about a fourth (or even less) of the price of the older seedlings. The older seedlings are generally preferred for dry land cultivation and the younger ones for irrigated cultivation, or in situations of good rainfall and moisture. Seedlings are usually got out from tracts where the cocoanuts are not grown under irrigation as the latter are believed to be less hardy than those grown under dry or semi-dry cultivation. It will also be necessary to make sure or have some guarantee that the seednuts were taken from gardens where the trees are heavy yielding and of good variety regarding size of the nut, yield of copra and so on and also from trees of proper age. The cocoanut is a cross-pollinated plant and trees cannot breed true to the parent; nevertheless when the seednuts come from gardens where the bulk of the trees are of one type there is a greater chance of the trees proving to be similar to the parent type.

Nurseries.—People who already own gardens and raise their own nursery for planting out and extension can attend to

all the important points in the selection of seednuts. Seednuts are to be taken from trees in their prime bearing stage, that is, exceeding thirty years and not from younger trees. It is believed that seednuts taken from younger trees take more years to come into bearing and that they are not very productive either. Seednuts are harvested from bunches which ripen after the main picking season which is the month of October is over, that is, from bunches harvested from December onwards. The selected bunches are allowed to remain on the trees until two or three of them begin to drop, when the whole bunch is harvested. The nuts are allowed to dry for about a month or two but not so dry as not to have any water in the nut. The cocoanuts should if shaken indicate that a little water is present. The ground for the nursery is well dug, roots and stems are removed, and the earth piled into the form of an elevated bed about 18 inches high, and 5 feet broad, and length according to the number of seednuts to be planted. If the number is large, then it will be well to make the bed in sections not exceeding about 25 feet in length. The top of the bed is well levelled and a lip or low bund formed all round. The seednuts are now planted in the bed, laid flat at distances of nine inches from each other and about an half an inch of the body showing above the level of the bed. The planting of the nursery is usually in the month of March or later on in August—September. The beds are watered regularly every three days and oftener if the soil looks dry. The bed is kept free from weeds. From about the sixth month the shoots begin to appear and if the nuts are not uniform then the germination is delayed and irregular. Seednuts planted about the end of September showed for instance a germination of about 60 per cent towards the end of April and the remainder came up slowly in the subsequent months. Likewise nuts planted in August can be seen with shoots of quite a foot high about the end of March in some cases and in others with shoots only just showing above ground. It is believed that if the seednuts contain more than the correct quantity of water, that is, are not quite and properly ripe for seed purposes, the germination is delayed. In about three months more or in about nine to ten months after being sown, the seedlings grow sufficiently large to be planted in their permanent places as 'seednut' seedlings. If they are not removed for this purpose then they are transplanted to another seed bed where they are put in wide apart, to remain until they can be taken out for planting after two or three years as 'geppe' (the name given in Mysore to such seedlings). For this purpose another nursery is made, the soil being prepared in the same thorough manner, and beds formed suitable for watering. In these the young seedlings are planted at distances of three feet each way. The beds are kept suitably watered, just enough to keep the soil moderately moist and never wet.

In some countries the seednuts are first made to germinate and then only put down in the nursery. For this purpose the seednuts are strung together in pairs and then laid astride branches of the jack or other tree near the dwelling house or on cross poles tied to uprights planted for the purpose. After germination they are taken out and put in the nurseries. By this method the nursery is filled completely and evenly with well sprouted plants and contains no blanks due to unsprouted or rotten nuts. The method is applicable only to tracts where there are frequent rains and the atmosphere always contains considerable moisture and not to inland tracts.

After transplantation into the second nursery there is need for manuring, hoeing and weeding. A thin sprinkling of sulphate of ammonia followed by watering now and then will greatly stimulate growth. Organic manures like cattle manure or oilcakes are not suitable on account of their tendency to attract insects or breed beetle grubs of different sorts. A mixture of common salt and ashes is a manure greatly favoured all along the coast both for the nurseries and for the grown-up plants put out in the permanent places.

Planting out.—Before planting the seedlings out in their permanent places, arrangements should be made for ensuring irrigation water, which will be necessary for watering the plants especially through the hot weather. If tanks and canals are not nearby, then wells should be dug and a supply of water assured. The ground intended for the cocoanut garden should now be prepared by clearing, levelling and the digging out of white ant nests if any are seen. The land should now be given two ploughings in the early rain and then the digging of the pits taken up. Pits are dug for putting in the plants about three feet square and two or three feet deep. The distances between the pits are very varied; in gardens under irrigation planting is very close, and often too close. The distance should be such that the fronds will not meet and interlace when the trees are full grown. The cocoanut plants are remarkable in the way they seek the light and bend away in order to clear any tree vegetation which shuts out the light and they suffer as much from the shade or obstruction of a neighbouring cocoanut tree as from that of a tree of any other kind.

A distance of about 24 feet each way may be considered to be the closest permissible. In the Mysore State large areas of cocoanuts are grown without irrigation; the distance is about 33 to 36 feet giving some forty trees to the acre. When it is remembered that the cocoanut fronds are from 18 to 22 feet in length, it will be seen that even this distance does not err on the side of being too great or excessive. Some growers claim that even with 40 feet the garden can be managed so as to give even a larger yield of nuts per acre, but this is

very exceptional. The 33 feet distance will be found about the most suitable in many respects. In irrigated gardens where the ground is dug annually instead of being ploughed and where the cultivation necessary for conserving soil moisture is not an equally important consideration, a smaller distance is usually adopted and about 50 trees are planted to the acre which will give a distance of about 30 feet between the trees. The abovementioned number of trees per acre are for square planting, which is the style adopted. If however the triangular system is adopted a larger number can be planted for the same spacing. For facility of cultivation with bullock implements however growers prefer the square planting system to the triangular. The pits are allowed to weather for a month or more and at planting time are filled with a mixture of sand and red earth in equal parts, the fully weathered earth removed from the pits being also used for the purpose if it is all uniformly good red earth. Seedlings which eventually grow into strong and vigorous plants are those which have a larger girth at the base. These will have to be selected in the nursery in preference to lean and 'leggy' ones. After the earth is allowed to settle for a few days, a shower of rain is very helpful if there should be one at the time. The seedlings whether of the 'seednut' kind or the older ones are transplanted into these pits, somewhat shallow so that the crown of the nut (*i.e.*, the base of the plant) is not more than four inches below the level of the mouth of the pit. It is believed in Mysore that cocoanuts should not be planted deep. The experience in many other places is quite different and cocoanuts are generally advised to be planted with the base of the crown about 18″ below ground, this depth being filled only gradually to ground level. This is probably on account of the different type of soils of the coast where a deeper planting is found to lead to the best growth. The best season for planting is immediately after the heavy rains, that is to say, in the month of August. The older plants may however be set earlier in the year about the end of March. Protected by regular hand watering in the first month, they have the advantage of the whole of the rains of the two monsoons and are sufficiently well grown to withstand the heavy rains without becoming damaged in any way. The young fronds are usually tied together loosely, either before or after planting, to protect them from being beaten about by the wind. A somewhat noteworthy practice in Mysore is to tie up the fronds of the older type of seedlings in the fronds of the wild date tree in such a way that the date leaves completely encase it as in a sheath from the base of the plant to almost the top of the leaves. This is with a view to preventing the rhinoceros beetle from gaining entrance into the shoot. It cannot be said to what extent this acts as an effective check; the tying up certainly protects the plants against the drying and mechanical action of the

wind, and also from injury when the interspaces are being ploughed close to the plants.

Operations in the new plantations.—The plants have to be regularly watered every day in the beginning and once in two or three days later on throughout the hot weather and in between the rains also if the soil should need it. The soil round the plants has to be frequently stirred, a close watch kept against white ants, rhinoceros beetle and cut-worms, which should be removed when the slightest trace is noticed. Stray cattle and goats have also to be guarded against as the young plants cannot survive damage to the shoots. Thorns are piled againt the base of the plants, or the 'Euphorbia tirucalli' is planted all round the plant, to keep away cattle, and in the case of the latter in the belief that it keeps out the beetle. In the first few years of the plantation it is usual to raise a crop of ragi together with its mixed crop 'avare' in the interspaces, or pulse crops like green gram, or cow pea, etc. Where plenty of water is available plantains are also grown in among the cocoanuts. The produce from these crops is sufficient to pay for the expenses of watering, watching and looking after the young cocoanut plants. As a matter of fact an arrangement is usually come to with smaller cultivators by which they undertake to look after the cocoanut plants in return for the privilege of cultivating the land with ragi. They receive in addition a money payment at the end of seven years at the rate of about Re. 1 to Rs. 2 per plant according as the owner gets a share or not of the produce of the grain crop. In the case of the plantain crop, it is believed to act in addition as a repellent of the cocoanut beetle, in the same way as the 'kalli' hedge is believed to act.. In spite of all care, timely watering, etc., some plants die out chiefly due to the white ant pest and the rhinoceros beetle, and replacements should be promptly made. For this purpose the older type of seedlings is made use of instead of the seednut seedlings.

The surface of the cocoanut garden is not allowed to cake up and harden, and immediately after the rains cease from about the month of November onwards the garden is ploughed generally three or four times and again, after the rains of the following year begin from about the month of April, the garden is ploughed another three times at intervals depending upon the rains. In the case of the mixed gardens and gardens having irrigation facilities, they are given one digging in the year about the month of September or October. These operations result in the rains of the year not only soaking deep into the soil but also being largely retained there for the use of the trees without being lost by evaporation. The young plantation not only shares in the manure which is applied to the grain crop but is also directly manured with the haulms of the pulses being ploughed in and a certain amount of new earth and tank silt being carted to the base of the trees.

The Plantation in bearing.—The trees begin to bear flowers in about seven years from planting. This may be deemed somewhat early for the average plantation. Bearing should be general about the tenth year, and delays thereafter should be put down to poor cultivation or set back due to other causes. The first inflorescences usually shed all their flowers and no nuts are borne, but subsequent ones begin to bear nuts. From about five years after the trees begin to bear, the trees are in full bearing. In about 12 to 15 years generally the trees must be yielding full crops. There is great variation in the number of bunches of nuts a tree may carry. The largest number at any time including spathes just opened out were 17 on the Mysore Government Farm at Babbur where several trees carried at the time 14 and 15 such bunches and inflorescences. One inflorescence per month or twelve in the year is a good average and at least ten are seen on even ordinary trees. Though the inflorescences appear only successively they follow quickly one after the other in the months of February and March when some six or seven inflorescences may appear. From July onwards another set of inflorescences appear which are fewer and open at longer intervals. The number of inflorescences is no sure index of the number of nuts that may be gathered. Due to various causes partly seasonal and partly by way of recuperation after a heavy crop-year many young nuts (called 'buttons' at this stage) drop away and only a few among the large number of the female flowers seen on a newly opened spathe remain even though they may have been fertilised and have commenced to swell. In good years however there is a strikingly large setting of fruits and the bunches bear a heavy crop. The number of nuts on a bunch is generally in inverse proportion to the size of the nuts which the tree bears; they are small in number in the case of very large nuts and *vice versa.* On the Government Farm in Babbur the largest number picked in a year off a single tree was 250 of average size nuts, but growers can point to individual specimens in their gardens known to produce over 300 nuts in the year. Such bearing is not unusual, and trees can be seen, especially about the dwelling houses and close to cattle stalls where they receive the sullage of the house and the washings from the cattle stalls, on which this number can be easily counted. These large yields demonstrate incidentally in an unmistakable manner the effect of manuring and watering on the yield. It has been found that the yield in any particular year is governed as far as rainfall is concerned, by the rainfall of that year and the rainfall of the preceeding year. It takes therefore fully two years before the effect of the favourable rainfall can be felt, and noticed on the crop yield.

Harvesting and Copra making.—Cocoanuts begin to be harvested in about eight months after the female flowers are fertilised. Harvested at this stage they are available for sale as

husked cocoanuts for the numerous domestic, religious and ceremonial uses to which they are put in Indian households. At about the same stage too they are used for the preparation of the copra. For this purpose the husked nuts are broken in two and put out to dry in the sun. A little drying makes it possible for the meat or kernel inside to be detached from the shell by a little levering, and this is now put out to dry in the sun or when the season is rainy is dried under artificial heat. The husk at this stage is also in a fit condition for being used for coir making purposes. There is also another stage at which the nuts are harvested, somewhat on a large scale in the Mysore State, and that is at the dead ripe stage when the nuts begin to drop from the trees. The nuts are either picked as they drop from day to day, or the bunches harvested when such dropping begins, which is the indication that the nuts have become dead ripe. These cocoanuts are kept stored unhusked until they become quite dry and then are husked and broken. The meat or kernel inside is devoid of all water at this stage and lies separated from the hard shell and can be heard rolling inside like a pea in a pod, when it is shaken. When the nut is broken the kernel rolls out as a brown-skinned hollow ball. This is an article greatly in use in different forms of confectionery, and other edible purposes, especially in Upper India where it is greatly in demand. Mysore supplies this demand to a large extent. The cocoanuts harvested in the first method cannot be kept long and are to be husked and sold for quick use or are made into copra straight away. In the latter case the cocoanuts can be kept for a much longer time and can be husked for copra (of this special kind) more or less according to market prices. The husks at this stage become very hard and the fibres very coarse and lignified and cannot be used for coir making. They are used only as fuel. To a small extent cocoanuts are gathered somewhat at a younger stage when they are about four or five months old, for the sake of the liquid contained in them which forms a sweet and refreshing drink, and they are therefore largely in demand especially in the summer months. There is an impression that the tree suffers damage by such gathering of these green unripe nuts, a belief which is due probably to the fact that if the bunch is cut at the base at this stage there is considerable 'bleeding' of the sap, which is likely to prove injurious. Plucking a cocoanut here and there in one or two of the bunches should not cause any such injury. Harvesting is not confined to any one of the above two methods in Mysore. Part is harvested for sale as husked nuts and part for making the special copra. It is customary to harvest for the sale of husked nuts about the months of September and October, and to reserve the later crop for harvesting for copra.

The harvesting of cocoanuts is sometimes concentrated in two periods, one in the month of October and another about April and May, when all the bunches which are in a more or less fit

state to gather are cut although they may not all be in one and the same stage of ripeness. More generally however the practice is to harvest about six times in the year as the nuts ripen and become ready. *If harvested regularly once a month as the nuts ripen the months of March, April, May and June between them will give about 50—60 per cent of the year's produce, the* remainder being spread over the other months.

Cocoanuts are gathered by pickers who climb the trees, test the fruits, cut the ripe bunches and then let them down along ropes or merely drop them to the ground. If the trees are not grown taller than about 25 feet or so, nuts are often gathered from the ground itself by the use of a long bamboo pole with a knife fastened at the end. If the bunches cannot be reached from the ground, then the man stands on a cart or a step ladder to help him to reach the bunches with the pole.

Yield.—The yield of cocoanuts per tree is a highly varying figure as already mentioned. There is variation not only from year to year in the same tree, but from tree to tree in the garden or estate in the same year. The variation in the performance of different trees is due in a large measure to the circumstance that the cocoanut is a cross-fertilised plant and seednuts give rise to trees which are not at all uniform. It is very seldom indeed that gardens are met with where even the bulk of the trees are uniformly high yielders. It is a great medley and the low yielders greatly bring down the average which the sight of a few good trees will make one anticipate. Average gardens can be reckoned to yield at the rate 60 nuts per year per tree, taking one year with another and all the trees in the garden the good, moderate and poor yielders together. An average of 70—80 should be considered high and a 100 nuts are exceptional.

For purposes of copra making however the number of nuts is only a partial indication of the performance of a tree or garden. Cocoanuts vary a great deal in the number of nuts that may be *required to give a definite weight of copra* (say a *maund* of 25 lbs.). The size of the husked nut, the thickness of the meat and probably its composition may all influence this number. In respect of the special copra of Mysore the variations among gardens (or varieties) is such that 1,000 nuts give copra all the way from 9 maunds up to 13 or even 14 maunds. Where estates therefore are worked only for copra, as in the case of the large plantations, it is really the yield of copra per acre that is of greater importance in judging the produce per acre. The outturn of copra depends also upon the age of the trees, the older trees give more than the younger ones. Similarly gardens on somewhat alkaline or salty land are stated to give a low outturn of copra than the soils of the better type, the former being harvested therefore only for ordinary cocoanuts.

Cocoanut 'Toddy'.—Cocoanut gardens are also worked for the sake of cocoanut 'toddy'—the fermented juice of the unopened

spathe of the cocoanut—either wholly or in part or for periods of two or three years as a change over from ordinary cropping for produce. This temporary change-over is considered beneficial to the yielding capacity of the garden in respect of nuts later on. Gardens which are thus tapped are usually very thickly planted and in most situations are regularly irrigated. The method of tapping involves much skill and judgment on the part of the tapper. Roughly, the method is as follows :—For the purpose of extracting the toddy the unopened spathes are first regularly beaten all over with a stick or the flat of a knife once a day for three days, whereby the surface is made somewhat flaccid; it is then wound over tightly with a palm leaf up to three quarter of its length from its base, and the free unwound portion is then cut off. A pot is now tied to this cut end for receiving the sap, the cut surface is bruised, scraped and sliced thinly every day and in a period of a week or so, the sap begins to flow; twice everyday the contents of the pot are collected, at the same time the spent portion of the end of the spathe is sliced off and the pot tied again to receive the next flow; the process is repeated every day till the whole spathe is worked over and finished. A spathe may yield up to 3 lbs. of sap per day as a maximum or 1·5 lbs. on an average. The quantity given by a single tree will vary with the number of inflorescences per year; usually 12 spathes are reckoned for each tree as a good average, which will mean some 500—600 lbs. of sap per year from a tree. The sap may, instead of being fermented into 'toddy', be made use of for preparing sugar or jaggery. The sucrose in the fresh untreated sap inverts rapidly on keeping and ferments into toddy; to prevent this inversion the pots into which the sap is received are smeared on the inside with fresh lime everyday before being tied to the spathe. In certain experiments in sugar making (in the Phillipines) it was found that the trees yielded from 300 to 400 litres per day (equivalent to 700—900 lbs.) and the sap analysed 16·5 per cent of sucrose. The sweet unfermented sap is boiled down to jaggery in the same way as sugarcane juice is converted into jaggery. The cocoanut jaggery is light coloured and somewhat soft as ordinarily made, in contrast with ordinary sugar cane jaggery.

Cultural Operations and Manuring.—The important operation in a cocoanut garden—other than the regular irrigations in irrigated gardens—consists chiefly of the periodical ploughings usually six in number referred to already. Sand, red earth and tank silt are carted every year and the ground round the base of the trees is dug out and then filled with new earth and sand. Cattle manure is also applied at the same time but in moderate doses, just enough to be scattered thinly over the new filled earth and worked in. The attack of the rhinoceros beetle is greatly feared and cattle manure which usually harbours them is not largely applied. Sheep manure is generally substituted and this is

secured by the penning of sheep which is somewhat general in many tracts. The penning is arranged for in the months of November and December, when the gardens are ploughed during and after the rains. Usually a thousand sheep are penned on the acre and this costs about Rs. 5 in cash, no food or perquisites being provided to the shepherds.

The growing of green manure crops for being ploughed in is an operation greatly to be recommended as most soils are exceedingly poor in organic matter and as most cocoanut soils are sandy. Both on account of the enrichment in nitrogen which the growing of leguminous crops will bring about and of the improvement of the physical condition of the soils the practice is important. Quick growing crops like sannhemp or cowpeas will yield sufficient green material within sixty days, and can be ploughed in about the month of July; the later rains will help to decompose the material thoroughly in the soil. Sannhemp is grown regularly in some gardens, cut down and left to rot in the soil. The crop can be disced in if grown in large estates with disc harrows, which such estates can easily own. The only objection to this growing of a manurial crop in this way is the possible depletion of the soil moisture, which is a very important consideration where cocoanuts are grown as a purely rain-fed crop in tracts of moderate rainfall. These crops are however to be grown in the early part of the year, and any reduction in the moisture content will be made up in the later rains; as an additional precaution against a reduction in soil moisture the green manure may be grown once in two years instead of every year.

Concentrated manures like oilcakes, bonemeal, fish manure and artificials are used with great benefit especially where rainfall is plentiful or irrigation available. The remarkable yield of cocoanuts from trees receiving the washing from the cattle stalls or the refuse from the household is a demonstration of the value of fertilising the trees liberally.

Judged by the amount of the principal plant food ingredients removed by the crop, the cocoanut should be considered an exhausting crop. The amounts of nitrogen, phosphoric acid and potash removed in the shape of unhusked cocoanuts by a tree bearing 128 nuts in the year is given by Sampson as follows:—

Nitrogen 1·93 lbs., Phosphoric acid 0·38 lbs., and potash 1·37 lbs. Taking 60 nuts as an average yield per tree and 40 trees as the number per acre, then the quantities removed per year from each acre will be 77·2 lbs. of nitrogen, 15·2 lbs. of phosphoric acid and 74·8 lbs. of potash. These quantities will be supplied by about 3 cwts. of sulphate of ammonia, about 75 lbs. of ordinary superphosphate of lime and some 150 lbs. of sulphate of potash approximately. Though it is well-known that the quantities of the different plant foods removed by a crop do not bear any direct relationship to the response the crop will make to the application of these ingredients as manures,

still it is a basis which affords some guidance and these quantities may therefore be applied to start with and modifications suitable to particular soils made as the result of actual experience.

It is a common belief that cocoanut trees have to be manured every now and then with common salt. It cannot be stated to what extent this belief is correct, but the belief is wide-spread and salt is largely used. In Bombay, cocoanut growers were being supplied with salt at concession rates for use as manure for cocoanut trees and for this purpose the salt was appropriately denatured to prevent improper use. In the coastal districts of Bombay, salt is used at the rate of 3 lbs., per tree.

The manner of applying fertilisers in general practice is to work it into the soil within a radius of about four or five feet from the base of the trees. The digging round the trees necessitated for this purpose leads to some amount of root pruning and the formation of new roots and the manures applied in among these roots stand a good chance of being absorbed to the immediate advantage of the trees. Although cocoanut roots travel far and the gardens are traversed by the roots throughout still there is always a crowding of roots near the bole of the trees, where the application of costly manures should prove most economical. Sheep penning and the ploughing in of green manure which benefit the far off roots if adopted as supplementary practices should prove a very efficient combination.

On the coast fish manure is often obtainable in large quantities and constitutes a cheap manure. They contain a certain amount of salt also. By itself fish manure is very much one sided. It contains (if it is not adulterated with sand) about 4·5 to 5 per cent of nitrogen and a like quantity of phosphoric acid and if the quantities of the plant foods removed by the crop are any indication at all of their requirements then the fish manure can be used if prices are suitable as a substitute for the superphosphate and applied at the rate of 3 cwts. per acre; this quantity will replace about 75 lbs. of the sulphate of ammonia in addition.

The following manure mixtures which have been found suitable may be usefully given a trial:—

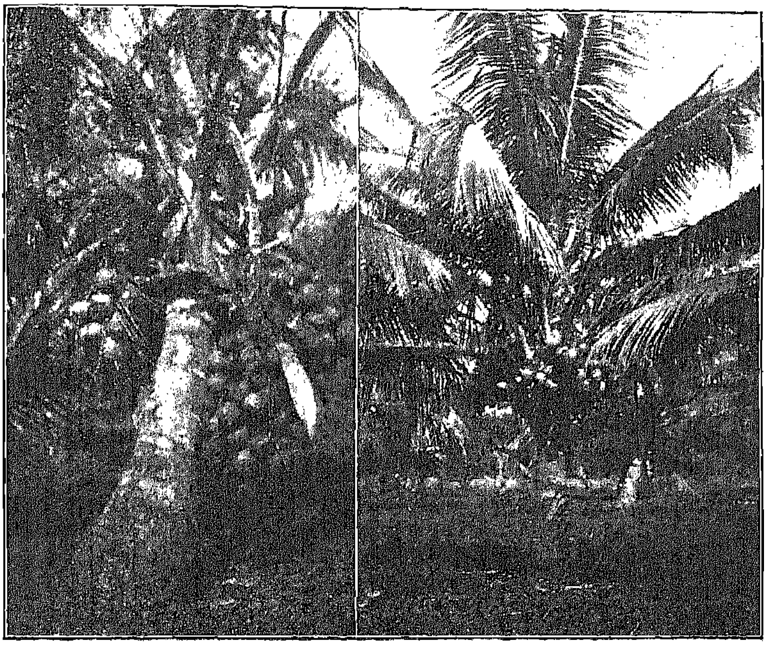
(1) A mixture composed of 50 lb. of compost, 1 lb. of bonemeal, 1 lb. of concentrated superphosphate, 2 lb. of muriate of potash and 1 lb. of common salt, to be applied for each palm in bearing. For palms up to 5 years of age one-third of the mixture and for palms up to 5 years of age one-third of this mixture and for palms up to bearing age, one-half of the same mixture may be applied. (Mysore Department of Agriculture.)

(2) A mixture composed of 150 to 200 lb. of sulphate of ammonia, 250 to 350 lb. of bonemeal and 150 to 250 lb. of muriate of potash, to be applied per acre containing 50 trees (Jacob and Coyle).

It must be noted that these mixtures should be applied when there is an abundance of moisture in the soil, from rainfall or irrigation.

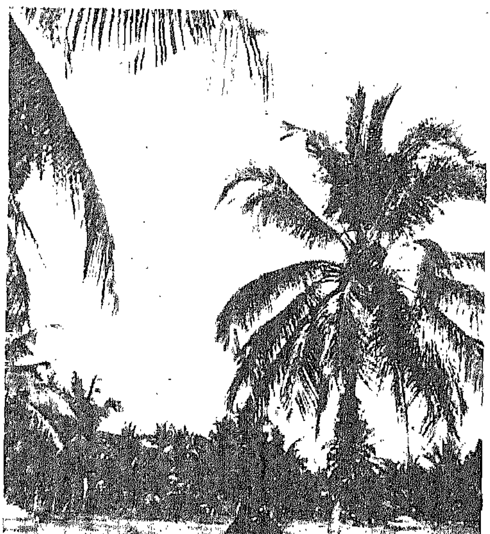
Botany and Varieties.—The cocoanut palm—'Cocos nucifera' belongs to the natural order Palmaceæ. It belongs to the pinnate-leaved group of palms. The stem is single and straight and somewhat swollen at the base, especially when the tree is young but otherwise uniformly cylindrical about 10 to 12 inches in diameter and marked by the scars of the fallen leaves. Very rarely (and certainly as a curiosity), the stem appears branched into two or more but this is always the result of the crown being damaged by the rhinoceros beetle and a number of buds springing, two or more of which grow into apparent branches. These are all usually rather diminutive although there is one tree in Mysore in which both the stems are grown of the normal size. The stem often gracefully slopes or bends which is the result of the tree attempting to grow away from adjacent trees which shut off the light. The stem may slant and then grow erect or turn about an obstruction and in these cases somewhat curious shapes result. The trees grow to a height of sixty feet and live to be a hundred years old. The roots spring from the short length of bole underground which in shape resembles an inverted cone and extends to a depth of about four feet and is crowded around with the roots. The roots have a great lateral spread of even twenty feet but are lacking in depth, being not more than four or five feet deep. They are peculiar in being of a uniform thickness all through, with the exception of the young rootlets springing from these which are thin and fibrous. The stem will send out roots from the leaf scars if it is covered with earth and watered. This property is made use of in shifting full-grown trees and transplanting them in a different place and sometimes even in lowering the height by digging under the bole and letting the tree sink slowly into it to the required level.

The leaves are pinnate but in the young plants the leaves are joined together by their margins. Trees are come across in which even the older trees have their leaves united together in this way but these are curiosities. The fronds in the full grown trees attain a length of 18 to 22 feet, they are erect at first and then open out and slant away, and droop when they are yellow and due to shed. A tree possesses some 25 to 30 fronds at a time. The fronds are broad and swollen at the base where they are attached to the stem and possess strong web-like bracts which bind them very securely to the stem. According to the variety the leaves have a tendency to remain semi-upright and not to slope away giving the crown a somewhat compact appearance as against others in which the leaves slope away much and give the crown a somewhat open appearance. In the first type as a result of this habit the bunches of cocoanuts are held more securely and do not drop. The tree comes into bearing in some seven years. The inflorescence appears in the axil of the leaves. The inflorescence is a spathe enclosing a much branched spadix, in the branches of which flowers are borne. The flowers are



Some of the very young and heavily bearing cocoanut trees on the Babbur Farm, Mysore State. [Mys. Agri. Dept.

A young cocoanut plantation. Note the way the plants are carefully tied up to guard against damage by the dry weather by knocking about and also by the cocoanut beetle.
[Photo by Author.



A view of a cocoanut garden. The well-ploughed surface, the lamb coops of sheep which are to be penned for manure, and the girdle-like guard for the stem for preventing thieves climbing up, may be noted. [Photo by Author.

unisexual, and both kinds are borne on the same spadix. The female flowers are usually borne nearer the lower end of the branch and the male flowers higher up. The male flowers are the first to open, they remain open for several days during which they are freely visited by bees. These flowers then drop away and then the female flowers which are like thick buttons somewhat like a flattish cone begin to be open and receptive to pollen which has thus to come only from other trees. The trees are therefore completely cross-pollinated. After fertilisation the female flower begins to swell into the young nut, and develops a short pedicel by which it is attached to the branch of the spadix. In a certain rare variety which is a curiosity, the branch carries a large number of female flowers closely packed which develop into nuts with no pedicels but directly attached to the branch resembling a fruit bunch of the palm 'Borassus flabelliferus.' The fruit is a one-seeded drupe; the pericarp is the fibrous husk which varies a great deal in thickness according to variety. Inside the husk is the mesocarp formed by a hard black shell at the base of which are the three 'eyes' or depressions over which the shell covering is very thin and brittle and through which the plumule of the germinating seed will eventually emerge. Below the eye within the shell and imbedded in the endosperm is the embryo. The endosperm which is the 'meat' of the cocoanut occupies the inside of the nut, lining the wall with a white firm and hard layer of material whose thickness varies from about one-third to one inch according to the variety. In the young nut the endosperm is soft and curd-like and becomes firmer as the nut ripens. During the whole of the developing period a sweetish sap fills the nut from which the developing 'meat' and other tissues derive part of the materials in their composition. In the ripe nut this sap or water becomes much reduced and finally as the nut dries it disappears completely. The meat becomes also dry and highly oily. In some varieties the meat at this stage is quite soft and can be easily pressed between the finger and thumb. The fruit drops from the trees when ripe and after a period of rest of about six months begins to germinate. Ordinarily there is only one embryo and so only one sprout emerges; but curiosities are seen in which there are two and sometimes three embryos, corresponding to the three 'eyes' and these 'polyembryonic' nuts sprout with two or three stems springing from the ground. During the germination process the meat or endosperm gradually disappears being dissolved and absorbed by the growing embryo which swells greatly in size during this period.

There are many varieties among the cocoanut trees ordinarily grown. Differences are seen firstly in the colour of the cocoanuts which are green, brown or dark brown. In each of these colour groups striking differences exist in the size of the fruits, which may be distinguished as large, medium and small. The large

cocoanuts may be as much as three times the size of the small nuts. The bunches in such trees contain only a few cocoanuts some five or six, while in the medium and small varieties the number may go up to 20 and 40, respectively. The size of the cocoanut may not correspond to the size of the nut inside or of the thickness of the meat; the latter may be larger and thicker in the medium and small varieties than inthe large sized cocoanuts. A tree which bears a large number of medium sized fruits per bunch is preferable to one which bears only a few and showy fruits per bunch. There are then differences in the shape of the fruits, they are longish and somewhat boat shaped in section and distinctly three cornered; at the other extreme the shape is almost rounded with corners considerably smoothened out; in between these are intermediate types in which the stem end is broad and flattish, the tip end somewhat pointed in some and somewhat the reverse in others. The thickness of the husk also differs in the varieties, some being very thick and others vary thin. This is of course related to the size of the nuts. In the extreme types of the first kind the nuts are very small, sometimes reduced into diminutive ones, and in others to nothing at all, the fruit being one mass of fibre and nothing else. At the other extreme are nuts which occupy almost the whole of the fruit, the husk being reduced to such thinness that it will have to be almost peeled off or at any rate removed very carefully indeed to get at the nut without breaking it. Between these two extremes all variations can be seen. A garden was once come across in which most of the cocoanuts were 'blind' consisting of nothing but fibre or with diminutive nuts of the kind used as little bottles or containers for 'kumkumam' powder in some households. The husk in one variety is sweet and can be eaten. Differences also exist in the fibre content of the husk. Differences are seen again in the thickness of the meat which as already noted may very from one-third of an inch to one inch. The meat differs in hardness and in the oil content. Though hard and firm in most varieties, in the so called 'butter' cocoanuts it is soft even though quite dry. They differ in their oil content also and oilmongers often distinguish between the ordinary and the more oily ones. Varieties also differ in the sweetness of the water in the fruit, some are specially distinguished for this quality and are often much sought after; one such, called 'Gangapani' in Mysore, is a green longish type of cocoanut which can be kept for many days and is gathered as a tender cocoanut for the sake of its sweet water. In addition to the range of colours mentioned above are the 'King' cocoanuts which are of a beautiful cream or very light orange colour, are almost round in shape and are esteemed for the sweetness of the water in them. Quite a different class from the ordinary cocoanuts are the dwarf and early bearing varieties sometimes called 'Nicobar' or 'Island' varieties. These begin to bear within three or four years even before the bole of the tree appears above ground, and

the fruits are borne so low that they can be reached by hand. When they grow up the stems are seen to be smaller in diameter than in the ordinary cocoanut trees; in these also the same range of colours in the fruits can be seen. The fruits are however smaller and there is a tendency to malformation and poor development in the nuts. Mention may also be made of a variety called 'kapuno' in the East Indies, in which the meat fills the whole cavity of the shell.

The so-called the Double Cocoanut or *Coco demer* distinguished botanically as *Lodoicea Sechellarum*, is a remarkable curiosity. The palm is a native of the Seychelle Islands and yields a fruit resembling two large cocoanuts joined together. The tree is extraordinary in its slowness of development. The seed nut according to the experience on the Peradeniya Gardens in Ceylon takes 2½ years to sprout; from pollination to the ripening of the fruit on the tree it takes nine to ten years. Trees nearly a hundred years old are still to be considered hardly full grown.

Insect pests of the Cocoanut Tree.—The most serious insect pest of the cocoanut tree is the 'rhinoceros beetle'—*Oryctes rhinoceros.* The attack is most serious when the trees are young, at which stage great care has to be taken to keep off the attack or at least to prevent it from damaging the plant. The beetle breeds in manure heaps, under trash and decaying vegetation of all kinds. The eggs are laid in these situations where the larvæ develop and later pupate. The adult is a black strongly built powerful beetle with a stout blunt horn on its head, from which its name the 'rhinoceros' beetle. It attacks not only the cocoanut palm but also the date palm and the various agaves. Eggs are laid in manure, in decaying stumps of cocoanut and date trees and other vegetable debris. The larvæ are the large stout whitish grubs found commonly in manure pits where they develop and pupate in the soil at the bottom of the pits and on the sides at a depth of 6 to 9 inches. Insects are found in all stages of development but a large emergence of the beetles takes place with the beginning of the rains in the month of June. They hide during the day and fly at night and if cocoanut plants are near about, the beetles settle on them and gnaw their way into the base of the shoot through and between the shoot and the bottom of the nearest leaf. Once inside the shoot, it cuts and eats away the shoot at this point and goes deeper into the shoot until the shoot is completely cut off and begins to dry. In such a case the plant altogether dies or tries to throw out another shoot which may grow into a twisted mis-shapen crown. If the presence of the beetle is discovered within a day or two of its entry into the plant and it is removed then the shoot survives, though when it grows and opens it may bear signs of the beetle attacks in the shape of a portion of the leaflets neatly cut off. Large grown up trees usually shake off the attack without any permanent injury except the cut across the leaflets but if the

attack is frequent, even such trees may be killed out or survive with curious mis-shapen crowns and for all practical purposes as useless trees. As many as five or six beetles may bore into one and the same tree and the trees may be attacked again and again. It is in the young plants and young bearing trees that the attack has very serious consequences.

There are many methods popularly believed to be effective in warding off the attack which are mostly in the nature of nostrums. The planting of the 'Euphorbia tiruculli' around the young plants, the tying of thorns round the base or of a sheath of wild date leaves tightly from the bottom to almost the top, the putting in of sand, and of salt in between the bases of the leaf stalks, the planting of plantains close to the cocoanut plants, burying the leaves of the *nux vomica* tree in the soil under the plants and grown up trees, manuring with the oilcake of the seed 'Hydnocarpus wightiana' and the use of fermenting oilcakes as traps are among the remedies which are supposed to keep out the beetle. Perhaps to some extent each of these has some effect. Bordeaux mixture sprayed over the leaf bases has been tried and found to be a good repellent, but the growth is so rapid that bare places are quickly exposed where the beetle can lodge. The only effective remedy is however to keep a close and daily watch on the plants, look for the signs of the beetle attacks, and where found, to probe into the hole through which the beetle gained entry and pull out the beetles. The entry of the beetle is made out by the slight quantity of grass which can be noticed at the hole and which is thrown out by the beetle. A stout iron wire of the size of an umbrella rib, one end of which is sharpened to a needle point with a slight cut like a barb is used for this purpose. The needle point is pushed carefully into the hole and pressed home, and then withdrawn. The beetle is thereby pinned through and is drawn out securely impaled on the barb end. All attacked trees are worked in this manner and the beetles removed and killed. The garden has to be gone over every day for this purpose. The attack is severe in some months and less so in other months. A count kept in a certain garden in the Kolar District of Mysore in which the attack was serious disclosed the following intensity in the different months:—The heaviest attack was in the period from the end of March to the middle of June, when the daily catch varied from 16 to 25 beetles. The next in intensity was the period from the middle of June to the middle of October with a daily catch of from 12 to 20 beetles. From then onwards the attacks declined up to the following March, the daily catch varying from 1 to 8. The number of trees in this garden was 1,000. The pouring of sand in between the base of the fronds and the centre of the tree and keeping it filled with sand has been found effective in certain tracts in Coimbatore.

Another method is to arrange for a sort of a trap. Trash heaps, rotten cocoanut logs, and cattle manure pits make very good

traps. The beetles resort to these situations for egg laying and breeding and by a periodical inspection of the heaps both larvæ and pupæ can be destroyed as they are found. If the beetles are not thus destroyed in their breeding places, trees are repeatedly attacked and even if the holes made at first are plugged with sand and salt or with the oilcake of the Hydnocarpus they cut their way through the plug to get into the shoot. Another trap which is also somewhat effective is to have pots here and there in the garden with a little castor oilcake or ground nut oilcake at the bottom, powdered and moistened with water. Beetles are attracted to this material and drop into the pot from which they do not climb out. They can be inspected every morning and destroyed.

Another very destructive beetle is the 'red weevil'—*Rhynchophorus ferrugineus,* which though rare does more serious damage where it is found. This beetle gains entrance into the tree top through the holes made by the rhinoceros beetle and unlike the latter breeds therein. The grubs gnaw deep into the crown going some 15 inches deep and this damage both by larvæ and beetles proves fatal to the trees. It is necessary that the holes made by the rhinoceros beetle should be closed with sand so as to avoid the red beetle from gaining entrance into the trees. Climbers who go up the trees to gather nuts should at the same time clean the trees of the old dried spathes, hook out beetles if any, and plug up the holes and also remove birds, nests, squirrels' nests and so on, so as to keep the crown free from both vermin and rubbish.

Cocoanut seedlings and young plants are subject to attacks by the mealy bugs (*Pseudococcus spp*) and scale insects (*Aspidiotus destructor, S.*). These infest the base of the shoot and of the adjoining leaves extending deep down into the clusters of leaves. The leaves become yellow and begin to dry when the attack is bad. If these are not removed promptly they multiply and retard the growth of the shoot, weakening it even to shrivelling point. The pests are easily got at and can be rubbed by the hand, and in the interstices, with a blunt rod. Among leaf-eating insects are the slug caterpillars of two or three species, but these are seldom serious pests. A leaf-eating caterpillar which has become a serious pest in recent years especially on the West coast is the '*Nephantis sarinopa, M.*' The caterpillar lives on the underside of the leaves and eats up the green matter of the leaves. Leaves dry up and the tree is weakened, and the yield is also reduced. The pest often attacks many fronds, and in many trees and becomes a serious one. It is to some extent kept under control by natural enemies. The cutting and burning of the attacked leaves is the only satisfactory remedy which should be carried out as soon as the pest is noticed.

The white ant is another serious pest of the young plants and if not noticed promptly and attended to, may kill the plant

altogether. In addition to the removal of the white ants' nests from and about the garden it should be seen that no dry sticks or leaves gather near the seedling. A stick is sometimes planted close to the plant to which it is tied to prevent the young plant from being much shaken by the wind. This dry stick is very soon attacked by the white ants which then attack any drying or weak tissues of the cocoanut plant itself. Such dry sticks should be removed or heavily tarred and then put in. Insufficient watering is often the cause of the drying or the poor condition of the plants, which has therefore to be remedied. In any case the plants should be frequently inspected and the plants freed from the ants then and there lest it cause serious injury.

Rats cause considerable damage to young cocoanuts many of which drop away as a result. They build their nests on the trees and as the leaves of the trees are very close together they are able to travel from tree to tree and practically live on the tree tops without coming down at all. These nests have to be pulled out and removed when climbers go up, but on the younger estates where the nuts are gathered from the ground itself the rats are never disturbed and are a source of permanent trouble. Monkeys cause serious damage in many gardens and commit so much havoc and are so difficult to keep away that cocoanut planting is not popular in these tracts. In order to prevent rats, monkeys and other animals from climbing up, a fairly efficient method is to tie a bunch of the leaves of the wild date palm all round the stem like a skirt with the spiny ends of the leaflets pointing downwards. This contrivance is tied up on the trunk about twelve or fifteen feet from the ground and covers about two feet length of stem. This acts as an effective barrier against these climbing enemies and if periodically renewed is able to protect the tree permanently. Another method is to nail a sheet of tin (a kerosine tin with the bottom removed, cut and opened flat) round the stem about fifteen feet from the ground like a tight fitting collar. The smooth surface of the tin does not afford a foothold to rats and squirrels which are therefore kept out. In both cases soon after these are put up climbers should go up the trees and remove the nests and chase down the rats.

Diseases of the cocoanut tree.—A common disease of the cocoanut tree is the 'stem bleeding' disease, which is due to the attack of a fungus, '*Thielaviopsis paradoxa.*' The stem of affected trees shows dry and somewhat sunken patches with many cracks in the surface with minute holes here and there through which a brown fluid exudes. The trees continue to grow for a long time in spite of the disease though they are gradually weakened and the crowns lose their healthy appearance and the yield is greatly reduced. The trees eventually dry up and die. The disease attacks fully grown up bearing trees and old trees. A favourite local remedy consists in drilling a hole in

the bole of the tree and letting out the sap; this does not however stop the progress of the disease. Another remedy which is more effective consists in chopping off slices from the patches on the stem which show the disease, singeing the raw surface thus exposed and then applying tar over it.

The 'budrot' disease (*Phytophthora*) is one of the most dangerous of cocoanut diseases. It is the same as the 'budrot' disease attacking the fanleaved palm, Borassis flabelliferus, among which it has been found to spread in a virulent form killing out large stretches. The cocoanut is only rarely attacked, but when it is attacked it is fatal. The leaves begin to drop and eventually the bud is also attacked, resulting in a rotting of the bud which means the death of the tree. No remedial measures are known, but attacked trees have to be cut down and burnt to prevent the infection from spreading further.

The cocoanut tree is also subject to a 'leaf spot' disease—'*Pestolozzia palmivorum*. Small brown oval spots with a brown centre and grey margins form on the leaves, increase in number, widen and coelesce as the disease progresses and the leaflets gradually dry up. The disease attacks even plants in the nursery. It can however be controlled by spraying with Bordeaux mixture of ordinary strength. In some cases following damage by this disease, there is an attack by the fungus disease, '*Botriodiplodia Sp*'. This gains entry through wounds or broken surfaces and causes the leaf to break and hang down. The remedial measure consists in cutting down diseased leaves with at least eight inches of the healthy portion included and burning it in the spot.

The uses of cocoanut.—The cocoanut is used for two important purposes, *viz.*, for use as an edible product and for the preparation of the oil. As an edible product it enters into the numerous Indian dishes for many of which it is indispensable: in fact there is hardly an Indian dish which it does not improve. It is an article which is consumed practically every day in even the poorest households. It is the ordinary ripe cocoanut which is used for this purpose generally but the dry copra (dried in the husk) is also used.

It is however as a source of oil that it finds its commercial and industrial use. For the preparation of the oil the ripe cocoanut meat is dried and made into copra. The copra is milled in the ordinary rotary oil mills of wood or iron or on industrial scale in modern milling machinery. Industrially the oil is used for the making of margarine and for the manufacture of soaps. In soap making cocoanut oil is used for producing hard soaps and these soaps can be used in hard waters and even in sea water. In India and other countries of production the oil is used as a cooking oil, for anointing the head and body, as an emollient and as a lamp oil. Cocoanut oil easily becomes rancid, owing to the oxidation of the free acids present in it. The same rancidity

takes place even in dry copra after some time. Cocoanut oil solidifies at temperatures of 60° to 65° F, and therefore remains as a solid in the cold weather even in the plains.

The chemical and physical constants of the oil are as below:— Specific gravity 0·926, Refractive index 1·439 to 1·443, Saponification number 246 to 260, Iodine number 8 to 10, Reichert Miessel number 6·6 to 8·4 and melting point 22 to 27° C.

The oil content of commercial copra is about 50 per cent.

Cocoanuts are exported principally as copra, and to a comparatively small extent as fresh nuts, *i.e.*, in the shell. The copra for export has to be prepared carefully, so that it may keep in a good condition during the long interval between its preparation and its use by the manufacturer and especially under the conditions of long ocean transport and may possess an attractive colour, shape, size and flavour. Large halves which retain to a large extent their shape without any buckling or shrinking, with also the original white colour maintained as far as possible, with no smell or sign of mouldiness or rancidity are favoured and the best are sold at a high premium. The oil content of the copra is also an important factor, though at the sales this is taken for granted. The oil content in the meat is at its highest only when the nut is old enough to drop of its own accord from the trees and this is the stage therefore when the fruits have to be gathered for purposes of copra making. After the nuts are broken, the halves with the shell are put out to dry in the sun on carefully prepared floors protected from the wind, against dust and also against the ubiquitous crow. After a few days the meat shrinks a little and can then be easily levered out of the shell without breaking. These cup-like halves of the meat are again dried in the sun to remove moisture further and in about seven days of good sun the copra is ready. As far as possible the picking of the nuts during the monsoons for copra making is avoided, but this cannot always be managed and even at other seasons rainy weather prevents sun-drying. Artificial drying is either over smoke fires under shelter or in specially constructed driers. In the former there is a considerable blackening of the nuts and the smell of the smoke also which greatly detract from the value of the copra. The drying is greatly hastened being often only a question of some hours as against the several days required for sun drying. Copra intended for use by the confectionery trader is specially dried with special care and packed. A good deal of copra goes in the form of sliced pieces as dessicated cocoanut and as shredded cocoanut which is used in the making of biscuits, confectionery and for other edible purposes almost exclusively.

Coir.—Cocoanuts furnish another important commercial product, *viz.*, coir. In fact the cocoanut may be regarded as a fibre yielding crop quite as much as an oil yielding crop. It will not be inappropriate to regard the cocoanut as a food crop,

as a fibre crop, and as an oil seed. The fibre of the cocoanut, called coir, is largely made use of for cordage of all kinds and especially in ships and all kinds of sailing craft. The fibre is specially suited for this purpose, as it does not decay or perish by use in salt water, as compared with the other important cordage fibres like Manila hemp, jute, etc. The fibre is aslo made use of for a number of other articles like coir mats, foot rugs, both plain and in various coloured designs, brushes, bags and as stuffing for sofas, carriage seats, mattresses and so on.

Coir is the fibre of which the cocoanut husk is largely made up. Fibre of the best kind can be obtained from the husks of cocoanuts which are not very ripe. At the stage of ripeness when the cocoanut drops from the tree which is the best as regards oil content, the husks are a little over-ripe for making coir of the highest quality. If the nut passes even this stage and begins to dry and the kernel to lose all its water then the fibre becomes very coarse and very dark brown and is fit only for very low grade cordage. At this stage the extraction of the fibre also becomes very difficult. For the separation of the fibre from the husk, the fibres have to be freed from the tough and closely adhering tissue in which it is embedded and for this purpose the husks are kept under water or retted, when the latter elements rot and loosen making the extraction of the clean fibre easy. The husks remain in the water, in special situations in the margin of the lagoons or back waters on the coast where the water is somewhat salty and are protected by means of suitable enclosures for a period of eight months or even one year. The retting is done in fresh water also and in this case the period is only six months. They are then taken out and the fibres are disentangled by beating the husks with heavy mallets and clubs. The fibre is well washed to free it from adhering pith and dried and put through some rough carding before sale. The outturn of marketable fibre is estimated in Ceylon at approximately 15 lbs. per 100 cocoanuts, and the total outturn of both bristle and mattress fibre about 20 lbs. Several processes have been patented with the object of avoiding this tedious process of retting. The period required is reduced to a few hours and the processes are applicable even to the fibre of ripe nuts. In one process the husks are crushed and treated with a mixture of lime or sodium carbonate containing a trace of aluminium sulphate at steam pressure for one to two hours. Nevertheless the time-honoured retting method still holds the field.

The various parts of the cocoanut tree are used for a variety of purposes too numerous to mention especially in the countries of production. For example, the trunk of the tree furnishes good building timber, especially for rafters, beams and pillars and the half sections when scooped out are made use of as flumes and gutters for carrying water; the fronds are plaited into mats and made use of for roofing for huts and dwelling

houses, as screen walls both indoors and outside and for making baskets and as umbrella tops; the midribs of the leaflets are used for making brooms, bird cages and fishing traps; the fronds divested of the leaves are excellent fencing material for gardens; the web like sheaths or bracts at the base of the leaves are used as sieves, the cottony tow adhering to the leaf sheaths form a good absorbent for applying to wounds; the sheath of the spathe is used as a receptacle for various articles and tied up like a hanging shelf; the base of the spathe is cut into short lengths and with one end beaten into a brush is used as a coarse brush for white-washing and painting; the branches of the inflorescence are used as tooth brushes; the husks are used as brushes; the under-sized nuts especially the dimunitive ones are used as bottles after removing the meat by scooping or rotting; the larger nuts too are used likewise for the keeping of oil and with elaborate workmanship are converted into ornamental vases; the two halves of the shells of the split cocoanut are used as ladles and drinking cups; the shells make excellent absorbent charcoal and are generally in demand for use in gas masks to keep off the poisonous gases used in gas-warfare. Reference has already been made to the sweet drinks, the sugar, the 'toddy', ropes of all kinds and articles made from it and to the oil and its uses.

The pithy tissues in which the fibre is embedded in the husk forms about 70 per cent of the weight of the husk and is a bye product for which no proper use has been found. It has been suggested that it can be used as a substitute for cork dust in packing and for being compressed into cork mats; it forms very good mulching material.

Cocoanut husks yield when burnt, an ash which is very rich in potash (35 per cent). The husks from 1,000 nuts will yield from 10 to 15 lbs. of potash.

The oilcake left after the oil has been extracted from the copra is an excellent cattle food. It is also a human food and is largely eaten mixed with jaggory especially by poor people. It has however to be fresh as it becomes rancid if it is kept for any length of time. Cocoanut oilcake has approximately the following composition:—Proteids 20·6 per cent, Fat 13·2 per cent, Carbohydrates 37·5 per cent, Crude fibre 14·2 per cent.

Production and Trade.—The total area under cocoanuts in India (including the States) is about 1,500,000 acres. More than one third of this area lies in the State of Travancore, the area in Madras is about 580,000 acres, in Bombay about 27,000 acres, in Mysore about 175,000 acres and in Bengal about 13,000 acres.

The foreign trade in cocoanuts and cocoanut products in India is very large. Copra is largely imported from abroad notably from Ceylon. The annual imports (1937-38) amounted to 49,383 tons valued at Rs. 95½ lakhs (in round figures) while the export amounted in the same year to 132 tons. Likewise India

is an importing country in regard to cocoanut oil. In the year 1937-38, the imports were 6,791,452 gallons of oil against 79,513 gallons of exports, the nett imports therefore amounted to 6,711,939 gallons of the value of about Rs. 77 lakhs. On the other hand, India is a very large exporting country in regard to coir, both raw and manufactured, and these amounted to 117 tons and 746,022 tons, respectively, in the year 1937-38. There is also considerable export of cocoanut oilcake, which in the same year amounted to 7,898 tons valued at Rs. 5¾ lakhs. The Mysore State exports large quantities of both cocoanuts and copra; in 1937-38, the export of cocoanuts amounted to Rs. 9 lakhs in value and that of copra was about 12,900 tons valued at about Rs. 40½ lakhs. Small quantities are also imported, which do not amount to more than Rs. 1½ lakhs in value.

V. LINSEED.

VERNACULAR NAMES FOR LINSEED :—*Kannada*—AGASI, ALASI; *Tamil*—ALIVIRAI; *Telugu*—AVISI; *Hindustani*—ALSI.

The linseed plant (*Linum usitatissimum*) furnishes two very important products, *viz.*, an oilseed yielding the well-known linseed oil, and flax, the famous linen fibre. The crop has a very wide distribution both in the tropical countries and in the temperate and colder zones. It is, however, only in the latter, that is, the cold countries that the crop produces high grade fibre and is therefore cultivated extensively for this purpose. Though in the temperate and sub-tropical countries the crop can be grown for its fibre as has been demonstrated in many parts of Northern India, the quality cannot compare with that produced in Europe and other cold countries. It is accordingly as a source of the oilseed that the crop is extensively cultivated both in India and the countries similarly situated. The Indian production of linseed is very large and the exports from India form a large portion of the quantity imported into Europe. The most important country other than India which produces and exports linseed is Argentine. In many parts of the world, notably Russia, the crop is the source of both fibre and of the seed and the Russian production of seed is one of the largest in the world. The crop is grown for the sake of fibre largely in Ireland and in Belgium in addition to Russia and the flax produced in the former two countries has the highest reputation for quality.

Climate, altitude.—The linseed crop is one generally confined to sea level or low elevations and the plains, as distinct from hilly tracts. As a seed crop it can be grown in higher altitudes also, as for example, in the Mysore plateau with its elevation of about 2,500 feet. Even as a fibre crop it has been grown successfully at this elevation.

The crop is one suited to tracts of low rainfall. It cannot stand much rain in the growing period and is quite unsuited to the Malnad. Most of the crop grown in India is raised after the rainy season is over, the water requirements of the crop being met from the moisture stored up in the heavy black cotton soils on which alone it is principally grown, or in the case of the lighter soils by a moderate irrigation. The growing season of the crop extends from about the month of September-October to February-March. It is seldom grown as a rainy season crop, whether it be in the early or the late monsoon.

Soils.—The soils on which linseed is grown largely are the black cotton soils, with their characteristic high clay and lime content. The largest area under the crop is in the Central Provinces and Berar where it is grown on an area of about 1¼ million acres and nearly the whole of this area comprises the black cotton soil type. In Bombay and Madras also the crop is confined practically to this type of soils. Linseed is however grown on the light alluvial soils of Upper India as in Bengal, Bihar and the United Provinces, but even here the more clayey soils are preferred.

Rotations.—Linseed is grown either as the single crop of the year or is preceded by one of the early season crops usual on the black cotton soils, such as black or greengram, coriander, short season groundnuts, etc., which are all harvested and removed by the end of August and leave the ground free for being prepared and sown with the later season crops like Bengal gram, wheat, linseed, 'bilijola' and the like. More generally however the linseed forms, together with its mixed crop, the only crop of the year, the ground being kept fallow and under preparation for this crop during the whole of the early season. When grown as the single crop of the year, it follows a crop of 'bilijola', wheat or Bengal gram, grown in the previous year in the rotation.

Linseed is grown both as a pure crop and as a mixed crop. When grown as a mixed crop it is grown in strips of six or nine rows alternating with a like width of wheat, 'bilijola' or Bengal-gram. Linseed is also grown as a margin crop around fields of wheat or Bengal gram, in strips as wide as may be desired all round the field, instead of in regular alternating strips common in mixed crop sowing.

Cultivation.—The preparation of the field for linseed on black cotton soils consists only in working it with a bladed harrow several times both to stir up the soil and to remove the stubble of the early season crop, in case two crops are raised in the year. The field is worked thoroughly in this manner during the months of July to September, or only for a short period in September-October if linseed follows a first crop. The sowing is in the month of October, when the heavy rains have practically ceased and the soil is sufficiently moist. Seeds are sown

in seed-drills in rows 9" apart; about 10 lb. of seed are required per acre. The seeds are sometimes mixed with ashes and powdered cattle manure in order to make the sowing even and thin. The seeds are covered by a light harrow. The seeds sprout in five days. Intercultivation to remove weeds and for earthing up is given after three weeks, more for the sake of the mixed crop than of the linseed crop which when grown pure is not earthed up. In the month of January the field is in full flower and the mass of delicate blue, mauve and white flowers with which the fields appear covered form a characteristic feature of the tracts of linseed cultivation in this season of the year. The crop ripens and is ready for harvest in February, which may go on in March also. The seeds have a tendency to shed easily, the plants are therefore pulled out when the capsules are just ripe and begin to open. Harvesting is both by pulling out the plants and by cutting them at the base, the former being however more usual. The plants are stacked on the threshing floor until they are dry and most of the capsules open. They are then spread out and beaten with sticks to thresh out the seeds completely, and the dry stems are shaken out and removed. The seeds are winnowed to free them from bits of leaves and stems and are further cleaned from adhering earth and fine gravel by being put through suitable sieves.

Yields.—A good crop of linseed yields from 400 to 500 lb. of seeds per acre. The crop is delicate and due to disease and the non-setting of seed, etc., the yields are often much below normal. On the alluvial soils of Upper India, very much higher yields are obtained than on the black cotton soils under dry cultivation. Yields as high as 10 cwts. per acre are obtained on those soils. The stems (or straw) are generally used only as fuel or thrown on the manure heap, although some amount of coarse fibre can be extracted even from such over ripe and somewhat coarse stems.

Linseed for fibre.—The second use to which the linseed crop is put is for the fibre, flax. Though it is believed that under Indian conditions linseed cannot be grown so as to give a sufficiently satisfactory yield per acre of flax of good quality and the crop has not been cultivated to any extent for the sake of its fibre, experiments conducted in the past and in recent years have demonstrated the possibility of the profitable cultivation of linseed for fibre. Some of the earliest trials were in the United Provinces. Seeds of both English and Japanese linseed were cultivated and surprisingly high yields of linseed straw (stems for fibre extraction) were obtained. The English seed yielded at the rate of about 2,500 lb. of straw per acre together with 450 lb. of seed. The Japanese seed yielded at the rate of nearly 1½ tons of straw and some 500 lb. of seed per acre. It was also found that the straw of the English seed yielded fibre at the rate of 17 per cent on the weight of the straw which is considered a very high outturn.

In the method of cultivation, the chief difference between the seed crop and the fibre crop lies in the seed rate, which in the case of the fibre crop is ten times as much as for the seed crop. The plants are thus made to come up very thick, to grow erect and without any branching. The seed rate is from 80 to 120 lb. per acre. It is also believed that for obtaining high grade fibre, seed will have to be got out from England, Belgium or Japan once in three or four years, if not every year, although there have been no experiments which could decide this point. The high seed rate and the need for importing seed both make the seed a costly item in the cultivation of the fibre crop. For fibre, the crop is harvested a little earlier than it would be for the seed crop. The seeds mature a good deal in the stack, so that both fibre and seed are obtained. Though the seeds are somewhat inferior, about the same yield of about 400 lb. per acre is obtained. After the seeds are threshed out the straw is taken up for the extraction of fibre. This consists in retting the straw tied up in bundles in fresh water. The retting is allowed to proceed for 3 to 4 days, after which the bundles are taken out, beaten and washed to remove all woody tissue and extraneous matter and dried. Alternatively, the retted stalks can be passed through a set of rollers as in a small sugarcane mill, the pith well broken thereby, and then combed out to free the clean fibre. Unlike the aloe, sunnhemp and other fibres, the linseed fibre is short and seldom exceeds 2′, 1½′ or even less being the average. The fibre is however very strong and can be woven into many kinds of textiles, both by itself and in mixtures. The fibre crop has recently been grown successfully on the red loamy soils of the Irwin Canal Farm in Mysore under irrigation.

Botany and varieties.—The linseed plant belongs to the order 'Lineae' or the Flax family, which comprises mostly herbs and shrubs. The linseed plant is an erect annual with a broomlike stem which grows to a height of 1½′ to 4′ and branches more or less according as it is sown thin or thick. The leaves are alternate, simple and entire, lanceolate in shape with a bluish bloom over the surface. The plants have a deep and extensive root system when they grow on the black cotton soils but in the Gangetic alluvium the root system is shallow. These differences correspond to differences in the growth of the above ground parts of the plant and in the yield and size of the seeds to such an extent that they may be regarded as cultivated races. The deep rooting varieties give seeds which are somewhat larger in size than the seeds of the shallow rooted varieties. The plants bear small disc-like flowers which are blue, bluish violet or white and very showy in the mass and are borne at the ends of the branches. The flowers are mostly self-fertilised and the varieties therefore breed true to a very large extent. Cross-breeding does take place but only to a small

extent estimated at about 3 per cent. The fruit is a capsule with five cells which splits and sheds the seeds, each cell contains about ten seeds, generally. The seeds are small, flattened and oval with a tough shiny coat which has a peculiar oily or soapy feel. The seeds are generally brown in colour with a slight variation in the depth. There are varieties in which the seeds are yellow and others in which they are white. These two are grown to a small extent in Central India and Rajaputana. They are richer in oil content and the oil is also of a lighter colour than in the brown seeded varieties. The latter themselves are distinguished as large and small. The extremes in size may be put down as 110 seeds per gramme in the large-seeded variety and 200 per gramme in the small-seeded variety. In the trade a considerable margin is recognised and for the large ones (designated "bold brown") the standard adopted is 145 with a margin up to 153, all sizes smaller than this grade being classed as "small brown". The oil content varies with the size of the seed. The larger the seed (up to a limit, which excludes abnormally large seed where the size is due to the thickness of the seed coat) the higher the oil content.

Pests and diseases.—There are no major insect pests to which the linseed crop is subject. Occasionally the caterpillar of a moth—the *Grammodes stolida F.*—is found feeding on the leaves, but the damage is insignificant.

A somewhat wide spread though not serious pest is the attack due to the larvae of *Cecidomyids* which suck the juice from the base of the flowers weakening the floral organs and inhibiting the formation of the seed. The incidence of the pest is largest in the months of February and March; early sown crops and early maturing varieties escape the pest, for which however there is no satisfactory remedy.

The crop is however subject to a serious disease, *viz.*, the 'linseed rust' (*Melampsora lini, Lk.*). This is generally present every year to a small extent but in some years becomes very severe almost like an epidemic. The leaves and stems become covered with bright orange coloured spots or pustules which later become reddish brown and black and crust-like in form. The disease greatly reduces the yield of the crop intended for seed, and in the case of the fibre crop makes it worthless. No direct treatment for controlling the disease is known. As a preventive measure, the burning of crop residues in the soil as well as the debris on the threshing floor left after the diseased crop was harvested and threshed is recommended.

Composition and uses of linseed.—Linseed is an oilseed which contains from 38 to 45 per cent of linseed oil, an oil which on account of its being a drying oil is used extensively in painting and varnishing. As expressed by mills, the seed yields only about 35 per cent of oil, while expressed by the country 'ghanas' the yield is still less being only 25 to 30 per cent. The

oilcake left after the oil is pressed out is a most valuable feeding cake, perhaps the most favourite cattle feed in Europe. It is a highly fattening food and is free from the costive effect which other seeds like cottonseed oilcake possess. It is fed to both milking animals and fattening animals. It has however the property of making the butter from the milk of animals fed on it, somewhat soft in texture. The seed itself when soaked in water swells up and gives a mucilaginous mash, which on account of this property is fed after soaking the seed, whole or after grinding, to animals in poor condition or recovering from illness.

The average composition of linseed and linseed oilcake, and the physical constants of linseed oil are as below :—

	Linseed.	*Oilcake.*
Moisture	... 6·6	11·5
Proteins	... 20·3	28·3
Fats	... 38 (variable)	1·00
Carbohydrates	... 29	31·3
Fibre	... 4·8	11·0
Ash	... 2·4	8·

Linseed Oil.	
Specific Gravity at 15°c. ...	·932 to ·936
Refractive index at 28°c. ...	1·479 to 1·480
Iodine number ...	180
Acid number ...	6·0
Saponification number ...	189 to 191
Unsaponifiable matter ...	1·50

(American Society for testing materials.

Production and trade.—The total area under linseed in India is estimated at about 4 million acres. The major areas are as under :—

Central Provinces 1¼ million, Bihar 586,700, United Provinces 318,300, Bombay 111,900, Bengal 137,000, acres. Both Mysore and Madras are very insignificant in respect of linseed production. The total production in India is estimated at 475,000 tons of seed. India is one of the largest linseed exporting countries of the world and the annual export of seed amounts to some 200,000 tons. In addition, both linseed oilcake and linseed oil are also exported, the former to the extent of 59,000 tons and the latter to the extent of 77,600 gallons per year.

VI. NIGER (Guizotia Abyssinica).

VERNACULAR NAMES FOR NIGER :—*Kannada*—HUCHELLU ; *Tamil*—PAYELLU, UCHELLU ; *Telugu*—VERRINUVULU ; *Hindustani*—RAMTIL.

Niger is grown for the sake of its seed which is an oilseed of considerable importance. The crop is grown over most parts of India, and may be said to be as common as the 'gingelli.' It is grown extensively in Mysore, Madras and Bombay, almost invariably however as a mixed crop with various grains and pulses. The crop is said to be a native of Africa but is grown at the present time over many parts of the tropical, and temperate zones. It is grown only under conditions of moderate rainfall not exceeding 40 inches and is therefore not suited to the Malnads and other areas of high rainfall.

Soils.—The soils most favoured are the light red and brownish loams of good depth and texture; light poor soils with considerable admixture of coarse sand and gravel are also sown, but the growth is always poor on such soils. It is either not grown or grown only to a small extent on the black cotton soils, or other types of heavy soils. In Mysore, it can be said to be confined to the first type of soils, much in the same way as ragi, in the case of the grain crops.

Rotation.—The niger crop is grown in the main rainy season commencing about July and is sown either about the same time as ragi with which it is grown as a mixed crop or is sown a little later in the month of September. It is seldom sown as an early monsoon crop or as an irrigated crop in the hot weather. Niger is almost invariably grown as a mixed crop and is followed or preceded by the same crops that are grown in rotation with the main crop. Ragi is the most important crop with which it is grown in mixture in the main season. Second in importance is the mixture of niger and horsegram, which is sown in early September. To a small extent it is grown as a mixture with other crops like groundnuts, castor, 'navane,' 'sajje,' etc. As a mixture with ragi, niger is sown in rows at distances of six to twelve feet and even in these rows it may sown either pure or mixed with the seeds of fodder jola, cowpea or 'avare.' Sown as a mixture with horsegram, it is sown at distances of not less than six feet, in plough furrows after the horsegram has been broadcasted and ploughed in. It is also usual to sow both crops through seed-drills in rows about 9″ apart and five or six rows of horsegram alternating with one row of niger.

Cultivation and yield.—The preparation of the land for niger is the same as has been described for the dry crops grown on the red loamy soils such as ragi, for example. When it is grown as a mixture with ragi, it has the advantage of a very well prepared soil, whereas when grown as a mixture with horsegram, the preparation of the soil is less thorough. This is especially so when the horsegram follows 'kar-ragi' or 'gingelli' as a second crop, as the time available for sowing does not permit much ploughing and cultivating. The crop however responds well to good cultivation and the growth in ragi fields and well prepared horsegram fields is always striking. Intercultivation is frequent and thorough for the ragi crop and the niger shares in the advantage. The crop comes into flower in three months after sowing and at this stage a good deal is cut and removed for use as green fodder especially for sheep. The crop matures in another five or six weeks, by which time the ragi is harvested. A curious feature is the large extent to which the leaves dry and shed in the field, for which reason it is considered sometimes a good green manure crop though it is not a leguminous crop like the usual green manure crops. The crop is harvested by cutting them with sickles at the base and is taken to the threshing floor and stacked.

It is taken up for threshing as almost the first crop on the threshing floor and is threshed by beating with sticks. The seeds easily separate and are then cleaned by winnowing and sieving. As in the case of the gingelli crop, there is a large admixture of earth and weed seeds and the produce from the threshing floor requires much cleaning before being sold or stored.

The yield depends much upon the proportion of the niger in the mixed crop. With the usual ragi-niger mixture, the yield, is only about 100 lb. per acre. Grown pure, however, the yield will amount to about 300 to 400 lb. per acre.

Botany and varieties.—Niger belongs to the natural order Compositeae. It is an erect herbaceous annual growing to a height of about three feet and branching only to a moderate extent. Both stems and leaves are rough to the touch due to the coarse minute hairs with which they are covered. The leaves are opposite, petioled and are somewhat lanceolate in shape, toothed and about three inches in length. The flowers are bright canary yellow in colour, about 1-2 inches across and are borne at the ends of the branches and in the axils, with a corolla of one row of ray florets and a disc of inconspicuous flowers, both being fertile. The seed is an achene about half an inch long, thin and needle-like, the seed coat being hard, glossy and black in colour. The cultivated crop consists of only one variety and no other varieties are seen.

Niger oil.—Niger seeds have an oil content of 40 to 45 per cent. In the country "ghanas" the seeds yield only about a third of this oil content. Niger seed oil is a clear pale yellow oil which is edible and is used largely as a substitute for gingelli oil, which itself often contains an admixture of niger seed oil. The oilcake is a valuable cattle feed and is largely fed to cows and buffaloes in milk. Ordinary niger cake from the country 'ghanas' contains about 4½ per cent of nitrogen. The cake is believed to make cows and buffaloes to which it may be fed drink large quantities of water and thereby increase the quantity of milk from these animals. The niger crop is not subject to any serious pests or diseases.

Areas.—The area under cultivation in Mysore is about 10,700 acres.

VII. SAFFLOWER.

VERNACULAR NAMES FOR SAFFLOWER:—*Kannada*—KUSUME; *Tamil*—KUSUMBA; *Telugu*—KUSUMBALU; *Hindustani*—KUSUM.

The safflower plant is the source of two important products, *viz.*, safflower oil and the safflower dye. The seeds afford the oil and the flowers the dye. The safflower dye was an important and largely used colouring stuff both in India and outside in the

days prior to the advent of the aniline dyes but has now sunk into insignificance. The plant is now cultivated principally for the sake of its seeds which are used for extracting oil and for eating. The plant is said to be under cultivation from very ancient times and its origin is variously held to be India, Africa (Egypt and Abyssinia) and Arabia. Its cultivation extends over many parts of the world both in the tropics and in the temperate zones and among the countries where its cultivation is of importance are India, China and the East Indies generally, Persia, Spain, Germany, Italy, Southern Russia and South America. In India, it is cultivated more or less in all the provinces but it is only in Bombay that it assumes importance, where it is the oilseed grown on the largest scale occupying an area of about 500,000 to 600,000 acres.

Rainfall.—Safflower is grown both as a rainfed crop and as an irrigated crop. In most parts of Bombay and in South India, it is nearly always a rainfed crop; but elsewhere in Bombay and in other parts of India it is grown mostly under irrigation. The crop is not fit for tracts of heavy rainfall, the general range of rainfall suited to the crop being between 25 and 40 inches.

Soils.—The rainfed crop is grown mostly on the black cotton soil; in fact in Mysore, Bombay and Madras, it is one of the typical black cotton soil crops; loams and light alluvial soils are also put under the crop extensively, both under rainfed and under irrigated conditions (generally the latter) in many of the other provinces of India.

Rotation.—Safflower is seldom grown as a pure crop; it is grown mostly as a mixed crop along with wheat, Bengal gram, or late season jola about three rows of safflower alternating with six or twelve rows of the main crop. A favorite method is to sow the crop in the marginal rows, so that the main crop of Bengal gram, wheat or jola is surrounded by the safflower crop. On account of the spiny character of the safflower crop, it serves to keep away stray cattle from the main crop when sown in this manner. Sometimes the crop is grown pure and this is especially the case where it is grown for the sake of the dye.

In the black cotton soils it may be preceded by an early monsoon short season crop of the kinds mentioned as suitable for this purpose such as greengram, blackgram, coriander, or short season groundnuts, and may thus form one of two crops grown in the same year. More often however it is the only crop of the year and is grown in the late monsoon. The crop usually follows cotton in the previous year and may be followed by the main season jola in the subsequent year. On the lighter soils and where grown pure and under irrigation it forms a rotation crop with various grain crops like jola, wheat, 'sajje' or even rice.

Cultivation.—The crop is sown usually in the month of October and even later in the season and harvested in February-March. The preparation of the black cotton soil is in the same

way as has already been described for the other crops of this season. The sowing is through seed-drills on the moist seed bed; the three-tined seed-drill is used and the crop is sown in strips of three rows alternating with six to twelve or more lines of the mixed crop of wheat or jola. About four to twelve pounds of seed are required per acre depending on the extent of the mixture in the main crop. After the crop comes up intercultivation with the light bladed hoe is given twice at intervals of a fortnight, principally for the sake of the grain crop. It is customary to top the plants about three weeks after the last intercultivation, so as to encourage branching. As the plants bear flowers only at the extremities of the branches, this process is rendered necessary to ensure a large number of flowers and a bigger crop of seed or dye. The crop matures in about four months and is harvested by pulling out the plants. They are stacked for a few days and when quite dry are threshed by beating out with sticks. The seeds thresh out easily and are then cleaned and winnowed. The leaves and stems are used as fuel or thrown on the manure heap. The yield of the seeds per acre varies a great deal depending generally upon the proportion of the safflower crop to the main crop of grain or pulse with which it is sown as a mixture. About 100 lb. of seed is usually expected in mixed cultivation and quite 400 to 600 lbs. when it is grown pure.

Safflower dye.—When the crop is cultivated for the sake of the dye the soil is prepared more thoroughly and it is also lightly manured. Seed is sown in October at the rate of 20 lbs. per acre. The plants begin to flower in January or February and the harvesting of the flowers is then taken up as it is the flowers or the corollas, which are brilliantly coloured, which contain the dye. For this purpose the flowers are cut off and removed when they are fully open and as far as possible before they begin to fade. The flower heads are put out to dry and are then broken up, cleaned so as to remove as far as possible everything other than the corollas of the flowers and then are packed for sale. The flower heads however form only the raw material or basis of the dye and the actual marketable dye is made from it by washing it in water and dissolving out the yellow dye which is easily soluble in water. After this easily soluble dye is washed out, the pulp which remains behind and which contains the more valuable and comparatively more permanent dye is dried and put up in small cubes for sale. An acre of the crop grown pure yields about 80 to 120 lbs. of dried petals. The dye furnishes various shades of red, yellow and orange, all of which have a tendency to fade. The dye is used for cotton, wool and silk.

Botany and varieties.—The safflower plant 'Carthamus tinctorius' belongs to the natural order Compositeae, and is classed under the sub-family Voluterella. The plant is an annual herb with slender many-branched stems, growing to a height of 18" to 24"; the leaves are alternate, toothed and have spiny tips; they are lanceolate in shape and about 3" in length. The

flower heads are borne on the terminal ends of the branches and the florets are coloured deep orange red. The outer florets are sterile and the inner disc flowers are bisexual. The bracts below the flowers have sharp spines. The fruits are achenes and are smooth, slightly ribbed or angular.

There are two varieties, one of which is very spiny and the other is either spineless or is only moderately so. The latter is more cultivated for the dye than the spiny variety. It is believed that the spines become less pronounced under cultivation but the spines persist a good deal in the forms under cultivation also and this character is in fact turned to advantage by sowing the safflower as a marginal crop where it acts as thorny hedge against stray cattle. Varieties also differ in the size of the seed, there being a large-seeded and a small-seeded variety.

Pests and diseases.—The safflower crop is not subject to any serious pests or diseases. The only insect pest known to attack the crop in South India is a green leaf-eating caterpillar—the *Perigoea capensis, G.*—which sometimes appear in large numbers and defoliate the plants. In the early stages the pest may be controlled by handpicking the caterpillars. Stomach poison sprays are useful but are not practicable on a field scale. The pest is much parasitised by flies and wasps and in this way is naturally kept down.

Seed and oil.—The safflower seeds yield a clear yellow edible oil which is largely used in Indian cookery much as the oil of gingelli or groundnut. Very often safflower seeds are mixed with gingelli and crushed for oil and a good deal of the safflower oil of the bazaar is a mixed oil prepared in this way. The pure safflower oil is also a partially drying oil. On long continued boiling over a slow fire for about four hours the oil turns into a thin plastic oil which can be used as a waterproofing material mixed if necessary with suitable colours. The hot oil if poured into cold water becomes a plastic of thicker consistency and is then suitable for use as an adhesive for glass. The safflower seeds have a white horny tough seed coat, which is only partly removed before the oil is expressed. The oil extracted from fully decorticated seed is about 25 per cent of such seed. The seeds are themselves edible as such and are fried and eaten. They form excellent poultry feed, also. The oilcake is an edible cake and forms an excellent concentrated cattle feed. It often contains a large admixture of the hard husks or seed coats which reduce the nutritive value of the cake and renders it a coarse feed as compared with other oil-cakes. On account of this varying quantity of husk in the cake the nitrogen content varies considerably. An average sample may contain 4·5 per cent of nitrogen but cleaner samples may contain as much as 7 per cent. The oilcake as it comes from the country 'ghanas' is in the form of dry, very hard lumps. The cake is reputed to keep long without going mouldy.

SECTION IV

SUGARCANE

VERNACULAR NAMES FOR SUGARCANE: *Kannada*-KABBU; *Telugu*-CHERUKU; *Tamil*-KARUMBU; *Hindustani*-GANNA.

The sugarcane forms the most important source of the sugar supply of the world and until about seventy years ago, when the cultivation of the sugar beet assumed great commercial importance, was almost the sole source of supply. Comparatively insignificant supplies are being derived from various palms such as the palmyra palm, the cocoanut palm, and the 'nipa' palm and from the maple tree and the sweet sorghum. The world's sugar production at the present time may be said to be divided between cane sugar and beet sugar in the proportion of 60 and 40, respectively.

Distribution.—India may be said to be the home of the sugarcane from where it spread both to the east and to the west. At any rate the cultivation of sugarcane in India is easily traced to the very earliest times; mention is made in the Vedas, Puranas and other ancient sacred writings as well as in the medical works of ancient India; the cultivation of the sugarcane was well-known and practised, the products of the cane such as jaggery and sugar were also produced and methods of making more than one grade of refined sugar understood and followed. Even in the modern development of the manufacture of sugar on a factory scale, India has played an important pioneering role and was at one time a large competitor with the West Indies in the English market for sugar. India has still an immense area of over 3½ million acres of sugarcane and a total production higher than that of any single cane growing country of the world.

The cultivation of sugarcane has extended far beyond the confines of India and is now carried on extensively in nearly every country where the climate is favourable. The important sugarcane growing countries of the world are:—India, Southern China, including the Island of Formosa, Java, the Phillipine Islands, the Hawaiian Islands, Central America, the Guianas, Brazil, Chilli, and Peru, the West Indian Islands of Cuba, Jamaica and others, South Africa, Egypt, the Mauritius, and Queensland in Australia. The relative importance of the sugar production of these countries may be judged from the ratio which their production bears to the total world's production of sugar, which were as below in 1933-34:—North America (all beet sugar) 6·99; The West Indian Islands, Hawaii and Central America 20·45; South America 6·39, Europe (all beet sugar)

27·89; China 1·07; Formosa 3·12; India 18·95; Java 2·97; Phillipines 5·57; Africa 3·66; Australia includiug New Zealand and Fiji 2·80;

The zone of sugarcane cultivation will be clear from the list of the cane growing countries given above. Though a tropical or sub-tropical crop, its cultivation often extends much farther beyond these zones. In the latter case however the cultivation is attended with serious difficulties. The reason is this: The growing period of sugarcane varies from about ten months as a minimum in the early maturing canes to as many as eighteen months in the late-maturing varieties. The upper limit is however very varied as some varieties can continue to make growth even for two years. The climate must therefore be such as to permit of continuous growth for at least ten months as in the case of the early-maturing varieties without frost or severe cold weather setting in before the end of this period. Severe cold arrests the growth and frost kills the cane if it is left standing; canes have therefore to be cut before they complete even this period and if frost or cold weather conditions are prolonged then elaborate arrangements have to be made to cover up the harvested cane with earth or cane trash or similar material and prevent the damage to the cane. Cane growing in these tracts is therefore at a great disadvantage; it can be seldom economic nor will the produce be able to compete with that from areas with the requisite climate.

Though climate naturally limits the areas of cultivation, still there are also other factors which decide the distribution of the area. Thus in India although the conditions which, as regards climate, may be called ideal, exist only in peninsular India or south of the latitude of Bombay the area under sugarcane cultivation is concentrated in Upper India and north of this zone. The Punjab, United Provinces, Bihar and Orissa have some 2,500,000 acres of cane and Bombay and Madras including Mysore have only 300,000 acres, that is, only about 11 per cent is situated in the best zone and 89 per cent is situated quite outside. The chief factor which has determined this unnatural ratio is the ease with which cane can be cultivated in Upper India without irrigation, coupled with the immense market for the produce. Irrigation is always a very costly item and even then is available only to a limited extent. Yields of cane in Upper India are very low but so are the expenses; under the irrigated conditions of Bombay and South India the yields are very high but so likewise are the expenses. It has been calculated that the cost of raising a ton of sugarcane is only about Rs. 5 or 6 in Upper India as against Rs. 9 in Mysore and Rs. 10 to Rs. 11 in Bombay and Madras.

Rainfall.—In South India sugarcane is grown under a wide range of rainfall conditions, varying from about 25 inches up to over 100 inches. In the malnad districts of Mysore the heavy

rainfall is concentrated in the South West monsoon months of July to September while in the East coast districts of Madras the heavy rainfall comes in the North East monsoon months of October to December. In the former case the cane is only from five to seven months old at the height of the monsoon while in the latter the cane is about nine to ten months old and nearing maturity. Though special efforts have to be made to secure adequate drainage of the surface water in the former case and against cyclonic storms in the latter the growth of the cane is not checked seriously and even if there is a slight check the cane recovers rapidly after the monsoon conditions cease. Nevertheless such heavy rainfall cannot be considered favourable. It is in the tracts of moderate rainfall of from 30 to 40 inches which is supplemented by sufficient and timely irrigation that the sugarcane thrives best.

Irrigation.—Irrigation is the most important requisite for sugarcane cultivation wherever it may be carried on. In regions of moderate or low rainfall its importance is obvious but even in regions of very high and torrential rains, as the rainfall is confined to a few months in the year, and alternates with dry periods of several weeks or months, irrigation has to be provided during these breaks of rainless months. As the sugarcane crop is one of practically twelve months' duration, irrigation sources such as river channels which provide only monsoon irrigation for a period of six months cannot suit sugarcane except where the channel water is stored in tanks for use in the hot weather or the channels themselves take from large storage reservoirs like the Krishnaraja Sagara of Mysore which will supply water throughout the year. It is under the large irrigation tanks therefore that cane growing is largely carried on, adequate provision being made by means of permanent or temporary wells for irrigation when the supply from the tanks gives out. These temporary wells also enable the cultivation to be started long before the tanks may fill and the young crop to be carried through with the moderate irrigation it may require until it grows and the need for heavier irrigation arises, which can be met by the tanks as they fill normally by that time. A very large extent of sugarcane cultivation in South India is also carried on solely or principally with the help of well irrigation or by water raised from springs and sub-soil flows or from great Artesian supplies as in the district of South Arcot. Though the ordinary 'mhote' or 'kapile' is the chief method of raising water, pumping installations using gas or oil engines or electric motors or even steam power have come into use to an appreciable extent all over South India and Mysore.

One of the largest areas in India depending upon a single irrigation project for its sugarcane cultivation is the Irwin Canal tract in Mysore from which the Mysore Sugar Company derives its supply of sugarcane. The interesting feature of this irriga-

tion is the block system which is designed in the permanent interests of the soils of the tract and of the health of the inhabitants. The irrigated areas under each of the large irrigation sluices are divided into three blocks on which crops will be allowed to be grown only in the following order, *viz.*, (1) rice, (2) dry or semi-dry crop and (3) sugarcane, during a three-year period, the irrigation being given or withheld suitably. A swampy condition likely to result as a consequence of rice being grown continuously and the risk of the spread of malaria are guarded against in this way, a judicious combination of crops and economy in the use of water being secured at the same time. Under the Nira Canals in the Bombay Presidency, large areas of cane are grown somewhat under similar control of irrigation.

Soils.—The soils suited for sugarcane cultivation are light coloured brown or reddish loams of some three feet at least in depth and underlaid suitably for drainage. In a great many places sugarcane soils are dark rich clay loams such as are to be found under tank irrigation. But these soils have usually to be improved by the addition of sand and red earth annually or at longer intervals. They require moreover by reason of their situation as well as texture, considerable drainage. On the other hand the cane grows luxuriantly on such soils and large yields are possible. They are also retentive of moisture and the crop can stand a certain amount of delay in irrigation. The quality of the jaggery made from cane grown on such soils is not however of the hard light coloured quality with the pronounced crystal grain structure such as is obtained from canes grown on the brown or light red loams or sandy loams, unless special care is taken in the preparation of the jaggery. The juice too is not of high purity in such soils. There is also a tendency on such heavy black soils for the cane to be somewhat delayed in maturity. In many situations under tank irrigation the soils tend to become alkaline and such areas require efficient drainage besides other methods of keeping down the alkalinity. Sugarcane on such soils not only suffers in growth but yields a juice which when boiled into jaggery either does not set hard at all or gives a very soft jaggery. When used for the making of sugar, the alkaline salts prevent the sucrose from crystallising out, the quantity of sucrose thus affected being found equal to the quantity of the alkaline salts present in the juice. Stony and gravelly soils are quite unsuitable and even though canes make a fair start on such soils, both growth and tillering are very poor. Deep alluvial soils inclined to be clayey loams rather than sandy are ideal sugarcane soils.

Drainage.—Sugarcane fields require ample drainage and on the class of soils on which it is largely grown adequate drainage will be invariably found necessary. These areas are generally flat fields and rice is the crop with which sugarcane is frequently

grown in rotation. Cane fields are often surrounded by or adjoin rice fields. Fields are also chosen as near to the tank as possible for the sake of a better water supply. All these conditions bring about a too moist condition of the sub-soil which is greatly detrimental to the sugarcane. A wet sub-soil retards the growth of the cane, predisposes it to diseases like red-rot, 'pineapple disease' and so on, and tends to increase the salt content in the root zone which as already explained affects the quality of the juice and the jaggery attempted to be made out of it. The sugar cane industry of the Northern Circars of Madras which was threatened with ruin some fifty years ago was saved by means of adequate and extensive drainage of the fields. Open drains of about three feet in depth are necessary on all the four sides of the cane fields for cutting out the seepage from the tank and from the adjoining fields, and inside the cane field itself open drainage ditches have to be dug at suitable intervals to prevent the sub-soil from becoming too moist or water-logged. Many soils which may appear alkaline or too clayey and unfit to grow cane can be converted into good cane soils by drainage. Sub-soil drainage can be provided not only by open drains but also by underground covered drains. It will be profitable to have these permanent covered drains of any of the cheap and crude types at least if not of actual drainage tiles. Drainage ditches can be filled with rubble, or date stems or even brushwood and covered over and in this condition will be found serviceable for a surprisingly long time as covered drains. A good scheme of sub-soil drainage with a proper main drain, laterals, etc., and a sufficiently low and effective outlet will be a good investment in areas in which sugarcane is grown every year as the main crop in rotation with a dry or semi-dry crop.

In regions of heavy rainfall as in the malnad of Mysore, drainage has to be provided mainly for the purpose of carrying away the surface flow in the rainy months and drainage trenches or deep furrows have to be provided. The custom in such tracts is to alternate the cane rows with trenches or furrows much deeper than the irrigation furrows usually are.

The great difference in the yield of cane that can be brought about by a difference in the degree of drainage is strikingly shown by the following result:—In one and the same field on the Hebbal Farm near Bangalore the drainage was good at one end and very poor at the other end and about intermediate in the middle. The growth of the cane was strikingly different in the three sections, the crop at the badly drained end being very poor and stunted. The crop was harvested separately from these three sections and it was found that while the well-drained end gave 31½ tons of cane per acre, the badly drained end gave only 6 tons and the middle one gave 22½ tons. In later years when the drainage had been improved by deep drains covered over, the location of the underground drains could be easily

picked out by the better and taller growth of cane on the rows lying immediately above the drains.

Rotations.—In a large majority of cases the sugarcane crop is grown in rotation with rice; the sugarcane stubble is removed completely after the crop is harvested and the land given over for the succeeding crop in the rotation, *viz.*, rice. Though this is the general practice, sometimes the sugarcane crop is 'ratooned', *i.e.*, the stubble is allowed to grow, the land is hoed, manured and irrigated and a second crop is thus raised. In rare cases a second ratoon may also be raised so that three successive crops of cane are raised one after the other, the first alone being planted and the second and third being grown only from the stubble. At long intervals other crops may intervene in the rice-sugarcane rotation, such as plantains, betel leaves, turmeric, yams and so on. Though the sugarcane-rice rotation is the common practice, there is much to be said against it and where conditions will permit, it will be a better practice to grow a semi-irrigated or dry crop in rotation instead of rice. The cultivation of rice and the puddling of the soil and its submergence under water for a period of five or six months of the rice cultivation spoils the tilth necessary for the succeeding sugarcane crop and makes the soil much too moist. It will be better, therefore, to grow a crop like groundnuts or ragi or jola or any of the garden crops as a main crop or a green manure crop like sunnhemp or daincha first and then follow it with a sugarcane crop. In the rice areas where sugarcane fields are few and are interspersed with the rice fields, this may not be possible but where compact single blocks under a single ownership are cultivated, there can be little difficulty in adopting the practice. When weeds peculiar to garden crops become badly established, notably the bulb-grass, Cyperus rotundus, which cannot be easily eradicated by cultivation, a crop of rice can advantageously be raised in order to smother and kill out such weeds. If rice has to be grown as part of the rotation, for the sake of the food grain necessary for the farmer and the straw necessary for his cattle, then it will be better to adopt the three year rotation prescribed for the Irwin Canal Tract in Mysore, *viz.*, dry crop—sugarcane—rice. In this rotation the rice crop only follows the sugarcane crop and does not precede it and therefore the harm to the soil is greatly reduced.

Planting Season.—The planting season for sugarcane is more or less uniform throughout South India. The main planting season extends from about the middle of January and February to the middle of April, that is from about the beginning of the summer solstice to the time of the vernal equinox. There is a second planting season which is of minor importance compared with the first and this is about the time of the autumnal equinox. The canes planted in the main season, *viz.*, February to April, obtain the full advantage of the

monsoon rains during their growth, develop an extensive root system and with the cessation of the rains make rapid growth and become mature and ready for harvest and milling when clear sunny weather prevails. The second season on the other hand does not enjoy the same advantages, the crop requires heavy irrigation during the period of rapid growth, and comes to maturity before the rainy season is over, making it very inconvenient to carry on milling and jaggery boiling operations. That the February—April planting is about the best season has also been proved by planting experiments on the Hebbal Farm where cane was planted at intervals of a fortnight and the yields compared.

The question of how long the planting season can be stretched assumes importance in the case of canes being grown for a sugar factory, because the longer the planting season the longer can the milling season be prolonged and the longer the period of work for the factory. In the case of the old established varieties like the 'pattapatti' or striped cane of Mysore, a somewhat belated planting, though it may mean a small reduction in yield, causes no serious trouble. In the case of the large number of seedling canes which have been introduced in recent years as the result of the sugarcane breeding work both in India and outside and which on account of their larger yield and other characteristics are largely replacing the old canes, the difficulty is enhanced by the fact that nearly all of them begin to flower or 'arrow' from about the month of October onwards. With the arrowing, the growth of the cane comes to a stop, so that if the arrowing takes place in eight or nine months in the case of a cane which normally grows for twelve months, then it means a material reduction in the tonnage of the cane. This is all the more serious because it is in the latter months towards the end of the season that the cane makes comparatively more rapid growth, and the cessation of growth prior to this stage means a much greater loss of tonnage than it would otherwise be. The harvesting of the canes cannot be put off to the end of the normal season and the canes allowed to stand till that time as deterioration sets in, the interior of the cane becomes pithy and dry and the juice content becomes less, although in composition it does not deteriorate for a considerable period. The earlier in the year therefore these canes can be planted, the longer is the period during which they can grow before flowering takes place; any advance in the planting season becomes a disadvantage. It is however seen that the new canes are not so very prone to arrow after they have been in cultivation for a few seasons and have become 'acclimatised,' so to speak.

Another important factor which decides the planting season is the advent of cold weather conditions in the higher latitudes. The interval between the beginning of the warm conditions favouring growth and the setting in of the cold season with the

risks of frost has to be taken advantage of in full by resorting to as early a season as possible for planting. On the whole, it may be said that, subject to slight variation depending upon local conditions of rainfall, supply of irrigation water and so on, the planting season now generally adopted, *viz.*, from the middle of January to the middle of April is the most suitable for the main season and the months of September to October for a subordinate season.

Planting material or "Seed".—Sugarcane is a crop which is propagated only vegetatively and the sugarcane itself cut into small lengths forms the 'seed' or planting material. Each of such lengths is called a 'seed set' and is so cut as to contain usually three eye-buds; sets may be cut longer or the whole cane itself may be used uncut; but in practice these longer bits are unsuitable, because of the need for maintaining a particular distance between one set and another in the rows or pits, for rejecting poor or diseased sets and planting only selected material and because the longer lengths are not straight enough to be laid in the rows. Seed sets may be cut from all parts of the cane from the bottom to the top and the full cane thus used for seed; or as is more often the practice only the top sets are used for seed. These top sets are formed by the length of cane about two feet or so in length at the growing end of the cane after the leafy top has been cut way. The internodes which go to make up such sets are nearly all of them still within the tightly enveloping leaf sheaths. This portion of the stem (or sugarcane) cannot be made use of for milling, for the reason that its juice is too rich in glucose and non-sugars and therefore detrimental to the setting of the jaggery or the separation of the sugar. They however form excellent planting material because their eye-buds germinate readily. To use the ripe portion of the cane for milling purposes and the growing top portion for seed purposes is therefore an ideal way of making the best use of the whole of sugarcane. It is however not possible to obtain the large number of sets required for planting from these sets alone; and this is especially so where cane planting has to be done long before the milling season. In practice therefore either the whole of the cane is cut up and used for seed or the top one third, one half or even two-thirds is used for seed sets and the remainder milled. Generally the younger the cane the better is the germinating capacity of the seed sets cut therefrom. In experiments to compare the germination of seed sets cut from different parts of ripe cane taken at the milling season it was found that the top sets gave a germination of cent per cent the middle sets 40 per cent and the bottom sets only 19 per cent. A high percentage of germination, quick and uniform at the same time, is of great importance in sugarcane cultivation. The seed sets are liable to white ant attacks and if sets do not germinate quickly and the shoots appear well above ground without much lapse of time

then they may not come up at all or, if they do, may die off before they can send out independent roots. Where cane planting is done in more than one season it is not unusual to sell crops of young cane of only six to eight months' growth for seed purposes. In some villages sugarcane is grown solely for being sold for seed in this way. It suits these growers because they may not have the water facilities necessary for growing the crop to maturity and it suits the buyers because they obtain seed sets of high germinating capacity at the proper time.

It is necessary to exercise great care in the selection of sound seed sets, especially as a precaution against pests and diseases. The 'red rot' of sugarcane (*Colletotrichum falcatum*) can be guarded against if seed sets showing the disease are strictly rejected. The cut ends of the affected seed sets show a characteristic red colouration in the pith of the cane and these can therefore be easily distinguished and rejected. "Mosaic" is another serious disease which, it has been proved, can be stamped out by rigorous seed selection carried out over a few seasons. Sets should therefore be obtained from canes which do not show the disease. Sets often show signs of borer attacks and these have also to be rejected. Care has also to be taken to see that all the eye-buds in the sets are present and in a sound and plump healthy condition; very often in the course of stripping the cane of trash or dry leaves and trimming it for milling, the eye-buds are damaged or knocked off altogether and the sets therefore do not carry the full complement of eye-buds.

A further selection of seed sets is sometimes carried out for their potential vigour by determining the specific gravity of the seed sets, which is based on the fact that sets with a higher specific gravity possess greater vigour. The method however cannot be applied on anything but a small scale such as for instance, as part of breeding technique.

Treatment of seed sets.—One of the worst troubles with germinating cane is the damage by white ants. Where the attack is bad, the whole of the interior of the cane set is eaten and the set does not germinate at all or if it has germinated, the shoot dries off. The attack is more in the red, light red and ashy-coloured loams than in the black somewhat clayey soils. Wherever irrigation cannot be given liberally and where canes are planted on the dry system depending solely on the rainfall, the pest is serious, and often as a precautionary measure the seed sets are treated in different ways before being planted. In the malnads of Mysore the sets are tied into bundles and kept submerged in running water for about 24 hours and then taken out and planted. It is claimed that a certain amount of sugar is removed by the water and the buds stimulated by this process. Elsewhere it is usual to rub the sets with some repellent material which will keep off white ants, such as kerosine oil, asafœtida, the stinking aloe, the juice of the *Clerodendron inermis*, etc. It

is doubtful if these give anything more than a very temporary respite. Heavy irrigations coupled with manuring with castor oilcake or sulphate of ammonia are more efficient means of keeping out the pest as they stimulate quick and vigorous growth and the ability to withstand the attack.

It is sometimes recommended that the seed sets should be dipped in lime water and then planted and it is claimed that a better germination and a higher yield of cane are obtained by this treatment. Cane sets soaked in a saturated solution of lime for a period of eight hours and then planted are reported to have given a higher yield of 25 per cent than untreated sets.

Composition of the sugarcane.—The sugarcane may be said to consist of the sugarcane juice and of the fibrous framework of cellulose which comprises the walls of the different kinds of cells which go to make up the structure of the cane and which hold the juice of the cane. This portion is called the fibre or 'mark'. The sugarcane juice is composed of water and of solids mostly dissolved but partly in suspension in a fine state of division. These solids consist of sugars and non-sugars; the former comprise sucrose and glucose and the latter consist of dissolved salts and considerable albuminoid matters, colouring matters, gums and waxes which exist in a suspended or semi-colloidal form in the juice. The juice from the central pith cells or tissue of the cane which is comparatively soft is very pure and contains only the sugars with a small admixture of non-sugars; the non-sugars increase towards the rind of the cane and at the nodes, which are all hard and difficult to crush. When cane is crushed under a light pressure as in a wooden mill, the extraction of the juice is very low but it is expressed mostly from the soft pith alone and is very pure. With the greater pressure exerted by a bullock driven iron mill, the extraction increases, the harder portions near to the rind and the nodes are also crushed and the impurities also increase.

Fibre or 'mark'.—The 'mark' is the fibrous framework of the cane and different varieties of cane differ in their mark content. The higher the mark content, the harder is the cane and the better able it is to maintain its erect growth. Such canes are harder to mill and under the same pressure do not yield as large a portion of their juice as the softer canes. The begasse or the refuse of the cane after it is crushed is largely composed of the mark. The begasse retains more or less of the juice according to the milling pressure exerted, but no amount of pressure alone can squeeze out all the juice from the begasse. Other things being equal, the amount of juice retained will depend upon the mark content of the cane; the higher the mark the more is the juice retained and *vice versa*. To exhaust the begasse of all the juice, the begasse has to be moistened with water and then crushed and the process repeated again and again

until the exhaustion is complete. This process known as 'maceration' is adopted in all up-to-date sugar factories. The mark content of the different varieties may range from about 9 per cent in the case of soft canes to about 12 per cent in the hard canes and even go up to 15 per cent in the case of the very hard canes. The maximum theoretical percentage of extraction of the juice possible from any cane will therefore be given by the difference between 100 and the percentage of mark in it.

Sucrose.—The quality of the juice is judged by its sucrose content when the cane is ripe for milling. Varieties differ a good deal from each other in this respect, and the range of variation may be from 13 or 14 per cent in the poor canes to about 23 or 24 in the case of the very rich canes; about 18 to 20 per cent may be considered fairly rich.

Of the two kinds of sugar in the juice, *viz.*, sucrose and glucose, it is the sucrose which gives the value to the cane. Pure sugar is 100 per cent sucrose and the higher therefore the percentage of sucrose in a cane the better it is and the larger is the outturn of sugar that may be expected. Sucrose is a solid crystallisable product and as, in the manufacture of sugar, the sugar is obtained by crystallising the sucrose out, the aim is to have as much of this particular sugar as possible.

Glucose.—The other sugar, *viz.*, glucose is a semi-solid and non-crystallisable sugar and from the point of view of sugar manufacture, should be considered an undesirable ingredient of the juice, although it is a sugar and a food and very sweet to the taste. Its presence in the juice retards the crystallisation of the sucrose, keeping its own weight of sucrose from crystallising out. Its presence even in trifling quantities in manufactured sugar spoils the colour of the sugar and makes it moist, especially in wet weather. Where jaggery is made glucose is not a serious disadvantage as the whole juice is boiled down into jaggery and the separation of crystal sugar is not the object. Still even here a high percentage of glucose, whether present in the juice or formed later on during the boiling process, is a serious disadvantage, as it will make the setting of the jaggery difficult and good hard jaggery, which will not run or soften in the monsoon season, cannot be made.

The percentage of sucrose and glucose in cane juice will vary according to the age or ripeness of the cane, and in the same cane according to the portion of the cane from which the juice is taken. The glucose in the plant system is the earlier formed sugar, from which as the cane ripens the sucrose is formed. Ripe cane should not contain in the juice more than 0·5 per cent of glucose, young sugar cane contains considerably more. The following will illustrate how the composition of the juice changes as the cane grows up:—

Composition of juice of six average canes from field planted in April and cut on the dates noted.

Date of cutting	Glucose	Sucrose	Total solids
21st November	2·17	11·75	14·6
6th December	1·33	14·1	16·0
22nd December	1·23	14.95	17·0
4th January	1·16	16·5	18·3
18th January	·85	18·4	19·5
31st January	·93	18·2	19·6
14th February	·69	19·6	20·9
21st February	·62	19·5	20·9
28th February	·53	20·0	21·0
21st March	·40	21·4	22·4

In cane which is left standing long after maturity, in cane which has lodged, that is, which has been blown down by the wind, or for want of sufficient rigidity or due to top heavy growth lies almost flat on the ground, in canes which are damaged by the gnawing of jackals, pigs or rats and in canes badly attacked by the borer, which have lost their tops and have many side-shoots growing as a consequence, there is considerable increase in the glucose content of the juice and a corresponding reduction in the sucrose content. For example, while the composition of the cane from a whole field averaged 20·59 per cent sucrose and 0·47 per cent glucose, the canes from a lodged patch therein had a composition of 16·1 per cent sucrose and 2·16 per cent glucose. Similar deterioration of juice takes place if canes are kept long after they are cut, or if the raw juice is kept for any length of time; further when the juice is brought on to the boiling pan and heated, the glucose begins to increase rapidly. These increases all take place at the expense of the sucrose, which breaks down into glucose (one molecule of the former spliting into two of the latter). Acidity in the juice, rise in temperature, ferment-causing organisms, all favour the breaking down of the sucrose, a process which is called 'inversion.' The inversion of the juice has to be prevented or kept down by appropriate means and the best way of doing this is by the addition of caustic lime to neutralise the acidity.

Salts—The salts present in the juice are compounds of sodium and potassium taken up from the soil. Like the glucose they also hinder the crystallising out of the sugar in sugar manufacture. Canes grown on soils with a high content of soluble salts take up appreciable quantities of such salts and their presence is often strikingly indicated by the somewhat salty taste and the soft consistency of the jaggery made from such canes.

Other Non-sugars.—The other non-sugars form an important and troublesome group of impurities. The colouring matters naturally tend to darken the colour of the juice and of the jaggery made therefrom. For the same reason they are

objectionable in sugar manufacture. They come from the rind of the canes, which vary from dark purple to light brown or red, striped red and yellow, greenish yellow or ivory yellow to smoky black, in the different varieties under cultivation. The eye-buds too add to the colour of the juice. The dark coloured canes yield dark coloured juices and the other tints also colour the juice more or less and even in the canes which are ivory yellow there is a greenish tint in the juices. The darker juices naturally yield a poor dark coloured jaggery and in sugar manufacture require careful handling. The colour is present only in the outermost thin skin of the rind and if this can be scraped off, such clean canes will yield juices similar to the yellow or greenish yellow canes.

The other non-sugars, *viz.*, the albuminoid matters are due to the protein compounds in the cane and the bulk of these are located at the nodes of the cane and in the eye-buds; varieties differ in the quantity of albuminoid matters contained in their juice. When the juice is heated, these albuminoid matters coagulate and rise to the surface of the juice and are removed in the shape of scum. In the manufacture of sugar and in the making of good bright coloured jaggery, the removal of the scum has to be very thorough as otherwise the colour of the product will suffer.

The rind also contains waxes and gums which pass into the juice on milling. Along with the other impurities these also interfere with the consistency and colour of the jaggery and of the crystallisation and separation of the sugar and are difficult to remove thoroughly. Much of these like the albuminoids are removed in the scum.

Juices are judged not merely on their sugar content but also on their "purity." The purity is expressed by the ratio which the sucrose in the juice bears to the total solids. These total solids are read off on a specific gravity spindle (Brix) and after the sucrose is determined in the juice the percentage of the latter to the Brix reading, after due corrections for temperature, is expressed as the coefficient of purity. In comparing one variety with another, the coefficient of purity is an important factor to be taken into consideration along with the sucrose content.

Botany and varieties.—The sugarcane belongs to the natural order Gramineae and the genus 'saccharum,' allied closely to the 'Andropogons.' The sugarcane is a tall cylindrical stem or stalk of varying thickness, length, colour and other characters. Its roots are fibrous and spreading but not reaching any great depth; the root system is generally not strong enough to afford sufficient anchorage to the stems, which are much subject to damage on that account. The root stock is a simple prolongation of the stalk, and from the nodes on it spring true roots, which spread around and under in the soil. Varieties differ greatly in their root range. The stem is composed of nodes,

and internodes, varying in number and length in the different varieties. The leaves are alternate and spring from the nodes, their bases sheath the stem for a short length and then bend away as the blade of the leaf; these leaf blades are about three to five feet in length and two to three inches broad, according to variety. They are mostly hairy, some to the extent of being called spiny. Varieties differ in the length, breadth and hairiness of the leaves. When dry the leaves mostly drop off but this tendency varies and in some the trash is difficult to remove and in others drops off by itself. At the base of each leaf and fully covered by the sheath is a bud, round, triangular or oval, and flat or plump and very prominent or inconspicuous, according to variety. The buds or eyes are embryonic shoots and when the canes are planted in the ground they sprout. They also grow into side-shoots on the cane itself, under various circumstances chiefly when the growing top is damaged. Around the nodes are small pits or dots which may be regarded as embryonic roots. When the cane is planted or when water collects at the nodes or leaf bases or the cane lodges, roots grow from these points. When the cane becomes mature it begins to flower. Many varieties either do not flower at all or if they do flower, bear only sterile flowers, as the sugarcane has through long continued vegetative propagation lost the normal habit of flowering and setting seed. The inflorescence is a long cottony panicle with a long pithy peduncle and reaching from two to four feet in length, and white or light pink in colour. The individual florets have three stamens and two feathery stigmas. Where the flowers are fertile as they are in some varieties, the ovaries swell and set seed. The seeds are yellowish brown in colour and are tiny and rounded. The flowering should not always be taken as a sign of maturity, as it very often occurs even when the cane is only a few months old; the phenomenon is rather baffling and a definite explanation is hard to give.

The sugarcane comprises three species, *viz*, 1. S. officinarum comprising the noble or thick canes, 2. S. sinense, which comprises the groups, Panshahi, Nagori, and Mungo (or Uba) and 3. S. Barberi, which comprises the groups Saretha and Sannabili, which form the thin reedlike canes. The classification of Indian canes into the above five groups is according to Dr. Barber. The number of varieties of sugarcane grown in the different parts of the world is very large. Until about twenty-five years ago the varieties though large enough in number consisted of varieties that had been well established and been under cultivation for a very long time perhaps even centuries. The science of plant breeding changed this situation in a remarkable manner and has been instrumental in evolving innumerable varieties. Every important sugarcane growing country has its sugarcane breeding section and each is evolving, testing and multiplying new varieties suited to its local conditions. The older varieties have largely

given place to these new varieties and progress is so rapid in the evolution of new canes that hardly is one variety under cultivation for five or six years before it is displaced by a better and a newer creation which itself in its turn gives place to a still better cane; further the number thus put into cultivation is only an infinitesimal fraction of the number actually evolved, tested and discarded as unsuitable. Any attempt to describe even some of the important new varieties of cane which have passed across the stage in recent years will be far beyond the scope of this book. We shall confine ourselves therefore to a brief description of the varietal characteristics in general referring to the varieties, old and new, especially in the Mysore State, and to some aspects of the work of cane breeding itself.

The characteristics in which cane varieties differ relate to the colour and hardness of the rind, the habit of growth and height, the thickness of the stem or cane, the richness and purity of the juice, the period of maturity, the tillering capacity, the length of the internodes, resistance to disease, fitness for ratooning, suitability to special conditions, such as poor soils, alkalinity or heavy rainfall and above all, the yield of cane per acre. A distinct coloration of the cane, such as deep purple, pink or pink and white, or smoky is a disadvantage on account of the difficulty of preparing white sugar or bright coloured jaggery from them. The hardness of the cane is an advantage where canes are subject to the ravages of jackals, pigs, etc., but entails more expense in milling and where bullock power is used, a reduction in the extraction. A good tillering capacity means a larger number of canes per set and consequently a larger tonnage per acre. The length of the internodes is one of the factors that governs the purity of the juice because the longer the internodes the fewer are the nodes and the eye-buds, which are the parts of the cane that account for the bulk of the non-sugars in the juice; in addition they are easier to mill. The length of the internodes may vary from 3 inches to 9 inches. The thickness of the cane is a factor which influences the quantity of the juice in the cane and of the outturn of sugar per acre; for the same quantity of juice a larger number of canes will have to be milled if they are thin than if they are thick. The thickness around the middle of the internodes may vary from 2½ or 3 inches up to 6 inches or even more in the case of the so-called 'elephant' cane. The thick canes are generally larger yielders. The shape of the internode is sometimes important, as if it is too rounded or bulging across the middle it is liable to split during growth. The richness and purity of the juice is of course very important as the richer canes will yield a larger quantity of sugar per ton milled than the less rich canes, in addition to being more economical in boiling. The period of maturity of canes may vary from ten months upwards to eighteen months and even two years; an earlier maturing cane will be a great advantage where the seasons

are short or the supply of water likely to be insufficient towards the end of the season. Canes are often required for being grown under conditions of high rainfall and a high moisture content in the soils, on poor soils or under conditions requiring considerable resistance to drought and there are varieties possessing these characteristics. Some varieties are very vigorous and are suitable for being ratooned once or even twice and this has great advantages under some conditions, especially as they mean a great saving of the time and labour involved in preparing the soil and planting a new crop. Resistance to disease and pests is a valuable characteristic and varieties differ considerably in their susceptibility. Above everything else is the important characteristic, *viz.*, the yield of cane per acre, which is generally a resultant of many of the characters indicated above, and the selection has to be made of the variety which will give the highest yield under the conditions in which it has to be grown.

Mysore varieties—(a) old.—The old indigenous varieties of cane in Mysore are soft highly juicy varieties which could be easily milled in the wooden mills of those days and are soft enough to be used as chewing cane. This same requirement set a limit to the thickness of the cane, and canes were only of the thin or moderately thick types; and in the latter case they were often split or cut into pieces before being fed into the mills. Foreign canes were now and then imported, especially in Upper India where factories with iron power-driven mills began to be opened and even in South India the introduction of new varieties came in the wake of the iron mill and factory equipment. The old indigenous cane of Mysore is the Rasdali of which there are two types, one thick and another thin. It is a very soft cane with a greenish yellow rind, matures in ten months, has a sucrose content of 16 per cent in the juice, gives a light coloured jaggery and yields moderately well. The internodes are much rounded across the middle and often split or crack. It requires ample irrigation and manuring and cannot stand hard conditions. Jackals and wild pigs cause havoc unless the crop is well guarded. A later introduction is the cane called "pattapatti," or local striped, which is said to have been introduced from Vellore. This is a slightly harder cane than the Rasdali, with a rind striped yellow and red longitudinally, is a vigorous grower, tillers well, grows much taller than the rasdali, is somewhat top-heavy and inclined to lodge if not protected suitably, gives a rich juice of high purity with a sucrose content which may go up to 22 per cent, takes 12 months to mature, yields a good quality of jaggery, requires heavy watering and manuring, and gives a high yield which may go up to 40 tons per acre. It cannot stand drought or poorly drained soil conditions and is prone to suffer from 'red-rot.' A third variety is the one called 'Cheni' or 'Marakabboo,' said to have come from China. This is a thin tall cane with a very hard rind, ivory yellow in colour; it tillers profusely, is suited to

conditions of deficient water supply, and even to soils slightly alkaline. The juice is very rich, the sucrose may go up to 21 per cent and the jaggery is hard and light coloured. It takes about eighteen months to mature. It is fairly free from the attacks of jackals and pigs on account of its hard rind. It arrows freely and is also subject to 'smut'.

Later introductions.—The varieties to come in next were four different types from the Mauritius, which were brought out for the Northern Circars as resistant to 'red-rot' and thereafter introduced into Mysore. All these were hard canes of a very vigorous tall and erect habit of growth with long internodes and were high yielders. They had the habit of arrowing freely. Among these the 'Red Mauritius' is the only one which has persisted and is cultivated even to-day, especially in the malnads where it is found to thrive very well under the heavy rainfall conditions. For the same reason it continues to be grown in Malabar also. This variety is remarkable on account of the fact that it became the parent of the innumerable seedling canes which have been evolved in Mysore. Among other foreign canes introduced into South India which have retained some hold may be mentioned Fiji B, a Barbados cane, somewhat thick and stumpy, with short internodes and with a very hard deep purple rind. It has been found capable of withstanding the storms of the cyclone belt of the Madras coast better than other canes and has therefore remained in cultivation.

(c) *The 'seedling' canes.*—All the old canes are being replaced by the new so-called 'seedling canes' which are the products of the cane breeder's work. These canes are obtained by the sowing of the true seed of the sugarcane The ordinary means of propagation in sugarcane is as is well known the vegetative method of planting cut pieces of the stem. The canes resulting from this method are exactly like the canes which were cut and planted, and retain all the characteristics of the latter, although there are some exceptions. If however the true seeds are sown in the same way as the seeds of, say, any grain crop, then the resulting progeny is highly mixed in characters. If the seed of, say, Red Mauritius should be sown, the resulting progeny may consist of of canes exceedingly varied in characters, many of them quite different from the Red Mauritius parent. They may be thick, thin, medium size canes, of several rind colours, tall, short, erect or creeping, of varying degrees of sweetness, tillering capacity, and so on, comprising specimens in which the several characters mentioned already are shuffled together in great variety. The sugar cane bears true seeds in the "arrows" or flowers, but it is not all varieties, that flower, nor do all that flower set seed. Only such among the local varieties that flower and give viable seeds can form the parents or starting points for the evolving of the new 'seedling' canes. Seeds may be taken from open pollinated arrows and sown, or definite combinations may be

attempted by selecting the parents and crossing them under controlled conditions. Both these processes have been followed in the cane-breeding work and some extraordinarily good varieties have been and are being evolved.

The mere sowing of the seeds and raising of the seedlings is easy enough; the seeds are sown broadcast thinly on elevated seed beds, covered over with straw and kept watered by a water can; in a week they sprout like grass. In two months the seedlings are large enough to be transplanted into the breeding plots, where they grow and mature like ordinary canes. The testing of the unlimited number of varieties and selection of the desirable ones require however several years and also a very large breeding area. A large number is rejected in the early stages being obviously useless and those that show promise are allowed to grow, propagated vegetatively for the next generation and the characters further studied and selections made.

Occasionally from some one or other of the clumps of any one particular variety of cane there arises a cane which differs markedly in appearance from its vegetative parent; this variation is called a "bud" variation or a "sport". Whenever such are come across, they are separated, planted and tested and if found to possess any specially desirable characteristics are selected for regular cultivation. Such a "bud" variation or "sport" arises purely by accident. But in recent years bud variations have been artificially brought about by subjecting the cane set to X-Ray treatment, to the chemicals like Colchicine, Carbon tetrachloride, etc. (which possess the property of causing a change in the chromosome numbers) and then planting such treated sets. There are a number of cane varieties which owe their origin to bud variation. In Mysore the variety called "Babboor striped" belongs to this class of natural and accidental sports but many new canes have been evolved by the X-Ray treatment also and are under cultivation. The Mysore seedling canes all belong to the class of thick or noble canes. H.M. 544 is a cane of great vigour and high tonnage and has a yellowish green rind. It was a popular seedling for some years, but has along with H.M. 533, and other seedling canes been replaced by H.M. 320, a very high yielding cane which matures in about twelve months. As the best all round cane this variety is being extensively grown; at present (1942) other varieties mostly of medium thickness are coming into cultivation in quick succession, such as H.M. 661, H.M. 647, H.M. 645, H.M. 659, H.M. 658, H M. 658 and several others.

The Coimbatore seedling canes which have attained a great reputation are mainly of the thin class intended for Upper Indian conditions; recently however the breeding of thick canes has been taken up and many good canes have been evolved in this class also. Co. 290, Co. 331, Co. 313, and several other well-known varieties all belong to the thin class. They have been

found exceptionally well suited to Upper India where they have now almost completely displaced the old local varieties. Among the thick canes of Coimbatore origin are the Co. 419, Co. 508, Co. 360 and others.

Cane breeding has not been confined to the use of sugarcane or the species 'saccharum' alone as parents but what are called "intergeneric" crosses have also been made between sugarcane as one parent and a different genus of the order Gramineae as the another. The latter have been Teosinte (in Mysore) and sorghum and the bamboo in Coimbatore. Very good crosses have resulted and some are already under cultivation, such as H.M. 661, which is a cross between Co. 28 and Teosinte.

Among the old South Indian local canes are some very high class canes like the 'poovan' which is a fairly soft cane, growing tall and luxuriant, very thick and juicy, and with a yellowish green rind, very long internodes and capable of giving very high yields. Another South Indian cane of a similar character is the 'Kaluthaiboothan', an equally vigorous and large cane but with an ashy white bloom on the rind.

The manuring of sugarcane.—Sugarcane is a crop which is generally heavily manured and which also responds well to such manuring. In Mysore, soil ameliorants like sand, red earth, and tank silt are added to sugarcane soils according as they are clayey soils, clayey loams or very light sandy soils. As much as forty cartloads may be put on an acre in this way and mixed in the course of the ploughings. A light preparatory crop of quick growing green manure, usually sannhemp, is sometimes raised, cut down and mixed with the soil. Many soils greatly lack organic matter and the addition of green material in this way is much to be recommended. It will be possible in this case to reduce the dose of cattle manure to be added to about twenty cartloads per acre. Otherwise about twice this quantity will have to be added. In the Irwin canal tract in Mysore, compost manure made from city refuse is being used to replace cattle manure in part. This material contains about 1 to 1·5 per cent of nitrogen and is used as a substitute for its own weight of cattle manure. In local methods of cultivation considerable use is made of the green leaves and flowers of the 'honge' tree (Pongamia glabra), which are buried in the furrows or trenches between the rows of cane. The penning of sheep is also resorted to whenever possible. None of these however will suffice for the production of really satisfactory yields unless large quantities of concentrated manures or fertilisers are also used in addition. The constituent to which the sugarcane responds strikingly is nitrogen. To the other constituents, *viz.*, phosphoric acid and potash, the reponse is little and even then is not commensurate with the cost of the fertilisers supplying these ingredients. It is also the experience in many experiments that the potash, far from increasing the yield, actually depresses it. This is very surprising, especially

if we consider the quantities of these three constituents which are removed by or contained in an ordinary crop of sugarcane. A twenty five ton crop on the Hebbal Farm of Pattapatti cane removed from the soil a total of 55 lbs. of lime (CaO) 56 lbs. of nitrogen, 68 lbs. of phosphoric acid ($P_2 O_5$) and 190 lbs. of potash per acre and these were distributed in the different parts of the cane as under:—

Parts	Cao	N.	$P_2 O_5$	$K_2 O$
Tops	5·78	9·43	14·04	52·52
Green leaves	12·68	20·77	10·82	56·37
Dead leaves	20·53	2·53	5·05	21·58
Cane	16·16	22·89	38·50	59·51
Total ...	55·45	55·62	68·41	189·93

Likewise in certain tracts on the east coast of Madras the quantities of these constituents removed by a 30 ton crop were found to be 80 lbs. of nitrogen, 50 lbs. of phosphoric acid, and 180 lbs. of potash or for a crop of 25 tons (to make the figure comparable with those of Mysore) 64 lbs. of nitrogen, 40 lbs. of phosphoric acid and 144 lbs. of potash. The large quantities of potash removed in both cases are very noteworthy and the lack of response to potash is therefore very difficult to explain. Many aspects of the manuring of sugarcane including even the fundamental ones require investigation and clearing up. In practice the dose of nitrogen to which there is invariably a most striking response is increased as much as may be commensurate with the financial results of the application. Thus, doses as high as 300 lbs. of nitrogen per acre are applied, made up partly of oil cakes and partly of sulphate of ammonia, the former for a more sustained effect and the latter for stimulating quick growth. As regards phosphoric acid, a small addition of 60 to 70 lbs. of phosphoric acid per acre in the form of ordinary superphosphate of lime is made not only because a small increase in crop does result but also because it is believed that the quality of the jaggery suffers and that the maturity of the crop is delayed if such one-sided manuring with nitrogen only is given. In the same belief, and also in the fear that the soil may deteriorate by successive cane crops with only nitrogenous manuring, small doses of potash manures are also given; the quantity is strictly controlled by the price of the article, being indeed left out if the price is prohibitive. The potash is given in the form of sulphate of potash in doses of one cwt. per acre. In general, about 20 to 30 cartloads of cattle manure as an initial dose, a fairly good dose of concentrated manures consisting of 5 cwts. of sulphate of ammonia, half a ton of groundnut oil cake, 1½ cwts. of concentrated superphosphate of lime and 1 cwt. of sulphate of potash should be given per acre. In very heavy manuring and when the cost of fertilisers is not very high

or prohibitive, even an additional 2 cwts. of sulphate of ammonia can be applied; this will bring up the nitrogen to about 250 lbs. per acre. It is sometimes advised that the nitrogen may be raised even still further and that up to 10 cwts. of sulphate of ammonia can be advantageously applied, but this is very exceptional.

Sets per acre.—The number of seed sets required for planting an acre will depend upon the closeness of the planting and of the kind of seed sets used, that is to say, whether they are long and contain many eye-buds or are short ones containing only three eye-buds. The latter is the usual practice and of these 10,000 sets will be required for an acre, as a minimum. The widest planting may be taken as sets planted in pits one yard apart each way and at the rate of two sets planted in each pit, this will require about 10,000 setts in round figures. Planted in furrows drawn three feet apart and with the sets placed end to end in these furrows this same number will be required. If furrows are made closer as is customary in local practice in Mysore, the number required will vary from 16,000 to 20,000 sets With the better varieties of cane, each of which will weigh about 4 lbs. on the average at maturity, there is nothing to be gained by close planting. When such varieties are planted at distances of three feet each way there should be about 5,000 clumps per acre, and with an average of four canes per clump, the yield per acre will be over 40 tons which should be called a very good yield. Canes may go up to 6 lbs. each in weight and with varieties of good tillering habit, the yields will be of course very much higher. Close planting is however resorted to in order to offset the disadvantage of poor growth and also to economise the use of water, as it is believed that much water is wasted if the rows are wider. Even sets with only one eye-bud have been planted in wide rows and good yields obtained in experiments in Dharwar, Bombay Presidency. The matter of great importance in seed sets is the soundness and vigour of the eye-buds, so that every one of them will sprout and grow quickly and uniformly.

The quantity of canes to be cut for furnishing seed for an acre will, of course, differ greatly from variety to variety according as the variety is a thick cane or thin cane. For example, in a thin variety like H. M. 602, 6,860 sets each containing three eye-buds weighed one ton; in the case of thicker varieties like H. M. 553, and Babbur Striped, a ton of similar sets gave only 5,900 and 3,500 sets, respectively. There is always a certain number of seed sets which have to be rejected, because they are not sound or because they become split when cutting; this wastage will amount to 3 to 5 per cent, and this percentage will therefore have to be allowed for in cutting cane for seed.

Tillering of Cane.—Closely connected with the spacing of the cane sets is the number of the tillers that may go to form a

clump of cane. The first shoot to appear from an eye-bud is the main or the mother cane. From the underground nodes of this main or mother cane, begin to appear other shoots at successive intervals and these gradually grow into canes, younger than the main cane by the interval of time between their appearance above ground. Such shoots continue to appear for several months after the planting of the cane and every time manure is applied, this process is stimulated. At the harvesting season therefore a clump will contain a fully ripe 'mother' or main cane and a number of other canes of varying degrees of ripeness, the older among them being fairly mature and those that appeared later being immature. As all these are harvested together, the juice of these latter class of canes reduces the quality of the mixed juice, with consequent detriment to the resulting product whether jaggery or sugar. It will be desirable to have all the canes comprising a clump equally ripe for milling, but, as this is impossible, it is attempted to see that the youngest cane in a clump does not differ very much in age from the mother cane or older cane, to keep the difference in fact within about three months. For this purpose all tillers appearing after about three months or four months from the planting of the cane are removed. Where the cane is planted wide, the tendency for such tillers appearing is more and the tillers as they appear have to be removed. Where the canes are planted closer, or where the growth has been very luxuriant, the tendency to tiller is somewhat suppressed and the newer shoots have no chance to grow being crowded out, so to speak. In practice therefore every endeavour is to be made to encourage profuse tillering within the first three months and later on to remove new tillers as they arise, so that the canes that are left and allowed to grow may receive the maximum nourishment and attention.

Varieties differ markedly from one another in their tillering capacity and in the case of the heavily tillering varieties, the spacing can be increased. The variety called "Cheni" in Mysore belongs to this class and the thinner varieties as a rule tiller more than the thicker varieties. In this variety (as indeed in many others) the first shoot is often killed by the shoot borer and this damage stimulates the appearance of the tillers materially. The Cheni cane can be planted quite 4′ or even 5′ apart each way, the free and the profuse tillering may often give rise to as many as a dozen canes to a clump, most of them maturing by the time of the harvest. Varieties also differ in the length of time they can be left standing after they have become ripe enough for milling, some can be milled over a period of three months while others deteriorate rapidly. Obviously the latter type of canes cannot admit of as much tillering as the former. Analyses of bulk juice from fields on which the milling was spread over some months are given below, to show how

good in this respect a variety of the non-deteriorating type can be :—

	Sucrose	Glucose
1st week of harvest	20·25	0·41
2nd do	20·76	0·33
3rd do	20·89	0·44
4th do	20·60	0·46
7th do	20·96	0·50
8th do	20·73	0·68
9th do	20·49	0·67

Even in the 9th week after the commencement of the harvest, the juice of this particular variety—the " Pattapatti or local striped " remained sufficiently high in quality and although the glucose content was slightly higher than at the beginning it was well within safe limits.

Method of Planting and Irrigation.—The soil for the planting of the sugarcane has to be very thoroughly prepared. Ploughing with deep mould broad ploughs or digging the soil with hand tools has to be given, and repeated after intervals for the weathering of the soil. Stubbles, weed growth and roots are completely removed, sand, red earth and tank silt carted and mixed, and if possible sheep also folded. Cattle manure is now carted, spread and ploughed in and then the furrows or pits for planting are made and the field laid out for irrigation.

The planting of the sugarcane sets is either in furrows or in small pits and the irrigation is by surface flow along the furrows or by watering with pails in the pits when the cane is young followed by furrow irrigation when the canes grow up or by means of sub-soil irrigation.

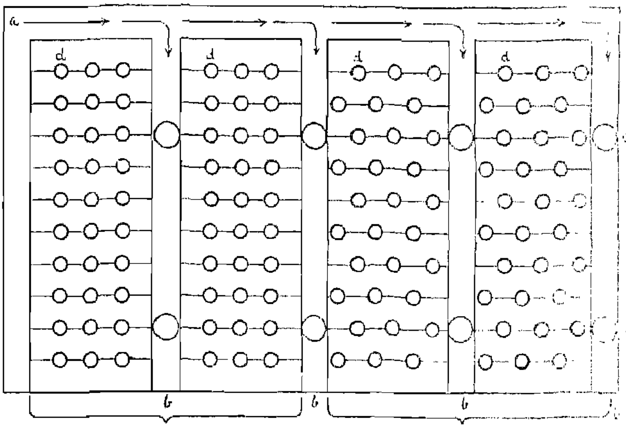
In the case of furrow planting, the distance between the furrows varies from 18″ to three feet, and though the former is rather the common old practice, it is being largely replaced by the wide 3′ planting. This wider planting has been standardised in the large cane-growing tract of the Irwin Canal area of Mysore as the most suitable. In this method after the field is well ploughed several times, cattle manure is applied and mixed and the soil levelled. Deep furrows about a foot wide and about 9″ deep are then made at distances of three feet from each other, and parallel to the irrigation ditch. The furrows are made either by a good ridging plough or by hand tools like large hoes or 'mammatis'; across these furrows and at right angles to the ditch narrow irrigation furrows are drawn at distances of 12′ from each other. From the irrigation canal water is let into these smaller canals or furrows and from these water flows into the cane furrows on either side one after another. After the cane grows up and the cane rows finally earthed up, these little irrigation channels are given up and are converted by a little earthing up into a dividing ridge between two beds. Irrigation

is then given direct from the main channel above the furrows; the water enters from this channel into the first furrow at one end of the furrow and flows along up to the dividing bund; at this end a little gap is made in the cane ridge through which the water is turned and flows in the opposite direction to the first furrow; after filling this furrow it turns into the third furrow through a similar gap in the second cane ridge and flows in the direction opposite to that in the second. All the furrows in the bed are thus irrigated one after another by a sort of a zig-zag flow. In the same way the beds are also irrigated directly from the main channel. The cane furrows in these beds are about ten feet long and take usualy eight sets. The length of the beds depend much upon the slope of the land, being limited by the size of the terrace. If the slope is slight or almost level, a bed may contain about twenty rows.

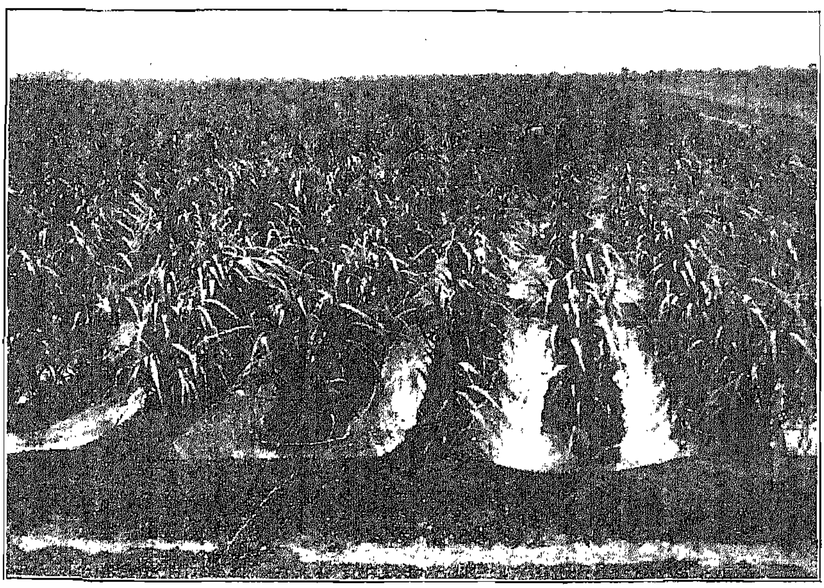
The pit system of planting is adopted on the stiff black soils in the areas under tank irrigation which are flat and somewhat difficult of drainage. In these places the cane fields are first well prepared by ploughing or digging and are then laid out into long narrow beds about nine to twelve feet wide and divided by trenches about two feet or two and a half feet in depth and 10" to 1' in breadth, and the earth from the trenches is thrown on to the beds. The beds are then well dug again and levelled and small shallow pits about 9" in diameter and 6" in depth are made in three rows in such a way that the pits are about three feet from each other. This is called the "square" planting. Alternatively pits are also made on the "scissor" style, or a triangular system. The pits are manured and then the cane sets are planted at the rate of two sets per pit. Water is allowed into the trenches, in which little depressions or "wells" are made at convenient distances. From these wells water is taken in pails and the pits watered frequently; as the canes sprout and grow up water is made to stand in the trenches and splashed on to the beds. In the later stages when earthing up has to the done, the clumps are earthed up individually into hills. Should the canes need it, which happens especially in the hot weather, the water in the trenches is also made to flood the beds by making it up back up by means of little bunds. When heavy rains set in, the trenches act as drainage ditches. In the tracts where this system is practised, a number of vegetables like greens, onions, radishes, coriander, etc., are grown as catch crops on the beds when the canes are young.

Elsewhere though the pit system of planting is followed, earthing up is done in rows of ridges, so that ridges and furrows alternate, and irrigation is given in the furrows. This system is followed when the need for drainage is not so great as in the first method of pit planting.

In planting cane in furrows in some cases the cane sets are planted in a double row in the furrow on opposite sides



Sketch showing the 'pit' system of planting sugarcane.
a,—Water channel.
b, b, b, b,—Trenches.
c, c,—Small depressions or wells in the trenches.
d, d, d, d,—Elevated beds with the pits for planting sugarcane, I, in the rectangular style, and II, in the triangular, or 'scissors' style.



The zig-zag method of irrigating sugarcane on a slope.

[Mys. Agri. Dept.

Portion of sugarcane field, showing how the canes are wrapped and tied together, a practice common in Mysore.

[Photo by Author.

of the furrow instead of in a single row in the bottom of the furrow.

The sets are planted by laying them flat and pushing them into the soft mud, or planted on a slant so that a short length of the cane set above the last eye-bud is sticking out and is visible. The cane sets should be so planted that all the eye-buds point sideways and not up and down; in the latter case the eye-bud or buds pointing downwards may not sprout properly and only those pointing upwards may come up, with the result that the germination is not full or uniform. With regular irrigation the cane sets germinate in ten to fifteen days from planting, and in another week the shoots are all showing well above ground and commence to grow vigorously.

Weeding, Manuring, Earthing up and Combating Borer Attack.—The rows are now weeded and with every weeding it will be advisable to give light doses of sulphate of ammonia or oil cake manure in order to encourage rapid growth and tillering. Germination may not always be satisfactory, owing to poor seed sets, or sets having been eaten up by white ants or due sometimes to borer attacks and gaps may occur in all such places. If these blank places are many then it will be advisable to replant in those places. For this purpose a small nursery should be available, which should have been planted simultaneously with the main planting and from this, plants in about the proper stage of growth will have to be transplanted in the gaps. With every weeding and manuring a light earthing up should be done also so that the furrow bottom or pits fill up gradually. In tracts where it is customary to apply the leaves and flowers of 'honge' tree, the flowers are spread in the furrows, and the leaves are laid in bundles along the middle of alternate ridges and buried in shallow trenches made in these ridges. In tracts where the attack by shoot borers is serious, a simple remedial method is, to earth up the cane lightly either by hand or by a shallow plough, so that the bases of the young leaf are covered with earth and the young borer larvæ cannot descend down along them into the heart of the shoot. Attacked shoots will have to be looked for from the time the canes germinate; these shoots begin to wilt a little and if removed at this stage they will be found to contain the larvæ which can be destroyed and further injury prevented. Removal of the shoot when it is dry and the attack shows up very conspicuously does not do much good as the larvæ have at this stage left the shoot and passed on to another.

About the third or fourth month from planting a heavy dose of manure, of both sulphate of ammonia and oil cake is applied in the furrows and the furrows are fully covered and earthed up by splitting the ridges, which are now converted into furrows. The application of oil cake at the different stages is most conveniently done by applying the powdered cake in the furrows. Cultivators do not wish to go to the expense of crushing the cake to

powder or purchase milled cake, and in such cases the cake is allowed to soak in water overnight when it crumbles into powder, can be stirred up in water and applied as a mash to the row. Another variation is to put a bag of oilcake in the place where the irrigation water enters the bed and allow it to be slowly washed in to the cane rows. Even after the cane rows have been finally earthed up, manure may have to be applied if the growth is not satisfactory, either in the furrows themselves or as is sometimes done in the case of sulphate of ammonia by pushing down a crow-bar or heavy stick near the canes on the rows and dropping the manure into the deep holes made in this manner.

Wrapping and Propping.—Further operations in the cane field are, wrapping and propping. Wrapping is the process which consists in bending down one or more of lower leaves of the cane and wrapping it around and close to the cane stem; at the same time the canes in the clump after they are wrapped are tied together. Any new shoots coming up are removed also at this time. The wrapping begins when the cane is about five months old and is repeated at intervals about four times. During the later wrappings two or more cane clumps are tied together for additional strength and to prevent their lodging. The wrapping is an expensive operation and requires considerable labour which has to be done by hand. An acre may require 20 men for each of the first and second wrappings, 15 men for each of the third and fourth wrappings. The local striped cane (Pattapatti of Mysore) and the Rasdali are top heavy canes and are liable to slant away considerably with the risk of breaking or being blown down flat, unless a certain amount of propping is done. Usually the tying together of the canes in a clump and of two or more clumps is sufficient to prevent any serious lodging, but in certain tracts, lodging is completely prevented by the use of strong bamboo props. For this purpose the tops of two adjacent rows are brought near each other and tied to a long leather rope running the full length of rows and fastened at either end by strong bamboo supports. In the cyclone belts of the east coast of Madras, this propping is invariably done and bamboo uprights and cross poles are used for this purpose. In recent years the cross poles have been replaced by more permanent materials such as thin wire ropes. Propping bamboo uprights and cross poles are said to cost Rs.150 per acre, and to last for three years.

The wrapping of cane though fairly general in Mysore is not carried out as a general practice elsewhere. The advantage of the practice is, besides what has already been indicated, firstly the protection of the cane from the attack of jackals, wild pigs, etc., which the close covering with the somewhat prickly rough dry cane leaves affords; in the case of the soft canes, this is a material consideration. Secondly the covering also prevents to a

large extent the splitting of the internodes which is common in exposed cane in the soft varieties; thirdly there is the general tidiness which enables labourers to move about with ease, in contrast with unwrapped fields which often look like an impenetrable thicket. Moreover in varieties with coloured rinds the colour does not develop if the canes are well covered and in these the wrapping is therefore a special advantage. Experiments conducted with a view to finding out if the wrapping leads to a higher yield per acre or conversely if the non-wrapping lowers the yield are not conclusive but indications are that it does not affect the yield. In the case of the hard erect canes of strong upstanding habit the practice can be dispensed with, as indeed it is done even with a local cane like "Cheni"; with the new seedling canes like H.M.320 now being grown extensively, no wrapping is attempted.

With regular irrigation canes make rapid and uniform growth. Whenever there is a lack of sufficient irrigation the internodes do not attain their usual length and become short, and portions of canes in which the internodes are shorter are those which developed when water supply was not adequate.

The optimum requirement of irrigation water on fairly retentive soils was found to be 95 acre-inches, including the year's rainfall, given roughly at intervals of ten days. On the loams and less heavy garden soils the requirement may go up to 120 inches. The months of May to November, that is, from the fifth to the tenth months, the irrigations are heaviest and during the early and late periods the requirement is comparatively less.

Harvesting.—When canes become ripe for harvesting and milling, the appearance of the leaves and the cane itself in some varieties slightly changes, the succulent tender green of the leaves changing slightly into a dry, yellowish and ripe tint. Depending on the variety, maturity may be looked for from ten months onwards. When the cane crop is considered mature, it is usual to confirm it by means of a trial boiling in which canes enough for one charge are cut, milled and boiled, and the ripeness of the cane judged by the quality of the jaggery. If good hard jaggery is made without difficulty, then the general harvest can begin. Ripeness can also be decided by a chemical test of the cane juice. For this purpose, average representative samples of the cane are cut from the different plots, say about six canes from each, and each lot is milled separately and the sucrose, glucose and the Brix are determined. Canes with a glucose content of half a per cent and less may be taken as ripe enough for milling. If canes begin to flower or "arrow" it is sometimes taken as a sign of ripeness, or rather as the sign that the correct stage has passed and the cane is over ripe. Though as a general rule canes flower only at the end of their growth, there are many cases where they do so long before they attain maturity. As has already been explained, it only means a

cessation of further growth and when it takes place much earlier than the normal period, a considerable reduction of tonnage. The juice continues to improve in quality and deterioration sets in only after several weeks. Arrowed canes can indeed be left for several weeks on the field without the juice losing quality.

It must be stated however that deterioration takes place in other respects if arrowed canes are left long without harvesting; thus the interior of the cane becomes pithy and hollow, and side shoots grow from the eye-buds. Whatever test may be used to decide the ripeness of the cane it will be desirable to confirm it by a trial boiling; this is especially so when a chemical test is not found possible.

Canes for milling are cut down level with the ground and are stripped of the dry leaves; the top is cut off where the internodes appear to be young, and from where the stripping of the young leaf becomes rather difficult. Some judgment is necessary as to how much of the top portion is to be cut off without including too much young cane and at the same time without losing much millable ripe cane.

The tops so cut and removed will furnish, after the green leaves are cut away, one or two sets each for planting. The cane is now cleaned of side shoots, if any, and the knife is passed over the full length to remove any prominent eye-buds. Milling should commence without undue delay after the canes are cut; if they are kept long, deterioration of the juice will take place. The following table shows the deterioration taking place in cut cane:—

Composition on	*Sucrose*	*Glucose*	*Brix*
3rd day after cutting	17·3	0·87	17·7
5th do	13·16	3·5	17·8
7th do	12·9	4·7	17·7
10th do	15·5	5·4	17·9
12th do	10·87	5·9	17·9
14th do	10·58	5·87	17·1

N.B.—Calculated on original weight of fresh cane.

The deterioration continues steadily as the canes are kept longer but the above figures are sufficient to show the extent of deterioration.

Where cane has to be transported long distances, delays are inevitable and the above table shows how detrimental such delays can be.

Milling.—The milling is conducted in bullock-driven mills or in power-driven mills and in the latter case either only in one set of rollers or successively in a series of several sets of rollers. In olden days cane was crushed in mills with a pair of wooden rollers or in a mill resembling a country oil mill. These have

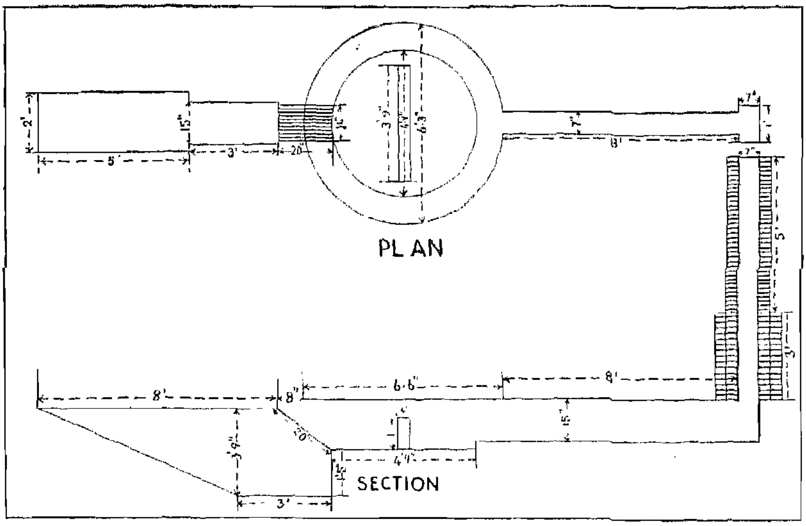
now gone quite out of use and the bullock-driven mill of three iron rollers is the commonest in use at the present time, and on its efficiency depends a good proportion of the returns from sugarcane cultivation. These iron mills will extract from 55 to 65 per cent of the juice calculated on the weight of the cane, a range which is equal to a difference of half a ton of jaggery on a crop yielding three tons of jaggery per acre. An efficient mill set up properly working and with the rollers in the best positions is of great importance. Both the mill and all the receptacles for holding the juice will have to be kept clean and washed with boiling water before work is started in order to exclude souring organisms as far as possible; for the same reason metallic vessels and receptacles are to be preferred to the earthenware pots or holders. The milling is to be preferably conducted in the cool hours and the juice boiled without delay. If the juice has to be kept for any length of time after extraction, then it has to be limed soon after extraction, and this is especially so if the receptacles are earthenware pots.

Jaggery Boiling.—The boiling of the juice is conducted over an open fire in large shallow iron pans with flaring sides. These may have a diameter of about three feet at the bottom, and six feet at the top, and are thirteen to sixteen inches deep. Pans are made sometimes of copper. The furnace is generally crude with no grating or chimney, sometimes not even an ash hole, and great quantities of wood fuel both logs and brushwood are used. The boiling of the juice from start to finish is conducted in one and the same pan, which when the charge is nearing completion, is taken down from the fire. Many improvements have however come in, in recent years both in furnace construction and in the method of boiling. Furnaces are now constructed with proper grating, baffle walls and chimneys and so are well adapted for fuel economy and for the burning of begasse or cane trash. Furnaces are again either single or multiple. The single pan furnaces use only one pan for the boiling of the juice, but the multiple pan furnaces are adapted for the boiling of the juice in two or three stages using two or three pans. Alternatively, the first two stages may be over one of the furnaces while the last stage may be over a furnace fired separately though connected with the main series or independent altogether.

From the sketch given of a simple single pan furnace of the improved type, the general idea underlying the construction will be easily understood. Two or more such single pan furnaces may be so constructed as to have only one chimney serving all of them. In multiple pan furnaces, the furnace is continued in two steps one above the other, the fires passing from the first or lowest to the next higher one, and from thence into the third or topmost one and then into the chimney, so that the heat of the fuel is utilised as fully as possible. In the

multiple types, the fresh juice is put into the topmost pan, where it gets moderately heated; it is then drawn into the second where it is further concentrated and drawn lastly into the lowest pan, *i.e.*, over the hottest fire; this pan is called the "strike" pan. As the juice is drawn from one pan to another, it is strained through thick cotton or woollen cloth and is considerably purified. As already stated, the 'strike' pan may be boiled over a separate furnace altogether and the main furnace may carry only two pans.

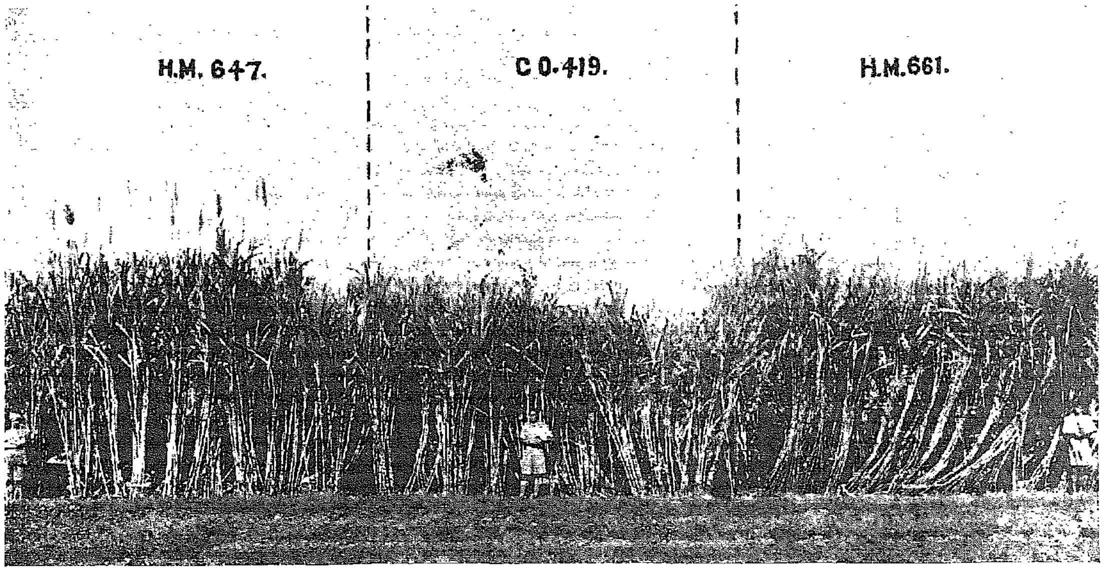
In the jaggery boiling process with the single pan, the fresh juice is first poured into the pan through a cloth strainer which keeps out bits of begasse, trash, dirt, etc. The quantity varies from 200 lbs. to 400 lbs., according to the custom of the tract, about 300 lbs. being more or less general. The juice is immediately limed by pouring freshly slaked lime water strained or decanted to free it from grit. Enough lime water is added to bring the juice to neutrality as tested by the litmus paper. The heating is now started. As the heating progresses, a dark coloured scum rises from the juice and continues to collect on the surface and becomes quite thick enough to be called a "blanket". The heating is controlled so as not to allow the juice to boil at this stage, so that the "blanket" firms up and is not broken. This scum is now removed by skimming off with a skimming ladle. All the scum is thrown on to a wicker basket lined with a coarse cloth which is placed over the pan supported on a pair of bamboos resting on the rim of the pan, or over a separate vessel. As the scum carries a certain quantity of juice with it, this arrangement makes it possible for this juice to slowly filter through back into the pan or other receptacle from which it is later transferred to the pan. As the heating proceeds more scum rises, collects in patches here and there, and is skimmed off. A good deal of the non-sugar materials in the juice coagulates and rises in the form of scum and the removal is a form of "defecation" of the syrup. The boiling proceeds vigorously and the juice goes on concentrating. A good deal of scum and impurities still exist in the juice and further cleaning is attempted by the addition of milk, white of eggs, or the mucilagious juice of the 'bendhe' (Hibiscus esculentus), all of which aid in coagulating the impurities which rise as more scum and are removed by skimming. The syrup now thickens very much and the boiling is brisk. The consistency of the syrup is now frequently tested to see if the charge can be taken down. Experience alone enables one to judge this stage; a little syrup is taken up at the end of a stick and held up, to judge the consistency from the way the syrup drips; or a little of the hot syrup is taken between wet fingures and kneaded under water to see if it will properly solidify. A thermometer can be used for affording some guidance, the temperature at the 'strike' stage is usually about



An improved type of single pan jaggery boiling furnace, sometimes called 'Sindhuvahi' furnace.

The step grate, the baffle wall and the chimney are the special features.

[Agricultural Department, C. P. and Berar.



Three different varieties of Seedling canes of outstanding merit.
Co. 419—a Coimbatore Seedling; H.M. 647 and H.M. 661—Mysore Seedling canes.

Mys. Agri. Dept.

118° to 120°C and the charge is generally ready to be taken down at this temperature. It is usual to attempt a certain amount of bleaching of the syrup during the last stages, and for this purpose a small quantity of sodium hyposulphite is sprinkled over the syrup and well stirred in.

The *boiling syrup in the pan is kept frequently stirred up* through its mass with a long handled stirring board, both to assist the evaporation and to prevent charring or "carmelisation". When the charge is taken down, the thick syrup is kept stirred up all through its mass with the same stirring board, to assist in cooling and crystallising.

When the charge is ready to be taken down, the pan itself is taken down from the fire or the contents are transferred to a separate pan or into a cooling trough by tilting the boiling pan into the latter; the syrup is now kept continuously stirred throughout its mass with the stirring board, it cools and thickens and considerable separation of fine crystals also takes place; it is soon ready to set solid, and for this purpose it is poured into wooden or other moulds of different shapes and sizes according to the custom of the place or is taken between the hands and shaped into balls, large or small. The commonest moulds give little truncated pyramids with bases about 3″ Square, of which one hundred will weigh about 60 to 70 lbs. Large and rectangular blocks are made by pouring the charge into a rectangular wooden box and cutting it into four or eight pieces by means of wooden partitions. The charge is sometimes poured into a rectangular depression on the ground about 2″ to 3″ deep and covered with a date mat in which the jaggery sets in the shape of a large thin slab about 1½″ to 2″ thick, and is then broken into smaller pieces. The ordinary zinc buckets or cylindrical vessels also sometimes serve as moulds, which give blocks like large cheeses. Very small wooden moulds are also used which give little cubes almost like chocolates. The moulds are made either in a single log of wood in which the moulds of the proper size and number are cut out, or by means of long sections which when placed side by side and clamped together form a kind of 'knockdown' type of mould board. In the first type of mould after the jaggery has set in the mould, the log is turned upside down and tapped with mallets, when all the jaggery cubes drop down. In the latter type, the jaggery blocks are released from the mould by loosening the clamping screw.

Instead of being put up as a solid mass of one or other of these shapes, jaggery is also produced in the shape of powder which resembles brown coloured sugar. For making this powder, the syrup undergoes a somewhat more thorough skimming and cleaning and when the charge is ready, it is transferred to the cooling pan, in which as it solidifies it is rubbed down in the pan itself by means of long-handled wooden mallets continuously without allowing any lumps to form until a fine yellowish brown

sugar results, which sells under the name of "makudam" sugar.

In the Malnad tracts of Mysore, the making of solid jaggery is not attempted, as even the best of such jaggery begins to soften and run in the rainy months. The charge at the 'striking' stage is transferred instead to mud pots or clean empty kerosine oil tins and either stored or sold in that form ; it keeps as a mixture in varying proportions of masses of crystallised sugar with molasses.

Quality and Composition of Jaggery.—The composition of jaggery varies a good deal, especially in the proportion of the sucrose content to the glucose, depending upon the efficiency of the method of jaggery boiling. Where liming has not been done or done partially, there is much inversion taking place which results in a high glucose content and a proportionately reduced sucrose content. In addition are various impurities due to poor filtration of the juice, inclusion of scum, etc. The following table gives the composition of a few typical samples :—

Sl. No.	Moisture	Sucrose	Glucose	Soluble ash	Remarks
1	6·1	79·7	6·6	2·7	Poor sample.
2	3·5	78·4	8·7	3·2	Do
3	9·5	70·0	15·6	3·8	Do
4	...	91·4	2·3	...	Good sample.
5	...	85·1	2·8	...	Average sample
6	...	81·0	5·8	...	Do

The points which decide the quality of a jaggery are its colour, cleanlines and hardness and its tendency to remain hard even in the wet weather. The colour is most important from the point of view of the ordinary consuming public, a light yellowish tint being most fancied. Good colour is generally attained by a complete removal of the non-sugar matters in the juice, and controlled heat to prevent caramelisation aided by some degree of decolourisation. The removal of the impurities and non-sugar matters is effected by the initial liming of the juice which brings down a heavy precipitate, besides neutralising the acidity of the juice and preventing inversion, and the consequent increase of glucose content and the tendency to softness in the jaggery. Any excess of lime darkens the juice and the jaggery and a slight acidity towards the end of the boiling tends indeed to lighten the colour. The removal of the non-sugars is effected only by mechanical means, such as through skimming and, where multiple pans are used, by filtering also, preferably through close woven flannel. To the extent to which these impurities are removed from the syrup, the colour improves. Caramelisation cannot be entirely prevented in boiling the juice in pans over a direct fire, but carefulness can reduce it considerably. Heating

by steam coils in what is called a " Wetzel " pan is adopted sometimes but is not profitable except when very high prices rule for jaggery. Decolourising the juice to some extent by the use of " activated carbon " to filter the partially concentrated juice is resorted to, as well as the use of phosphoric acid, and of hyposulphite of soda at the "strike" stage. These arrangements will require the use of two or three pans and a suitable multiple furnace. When jaggery of such purity is made, the outturn is naturally smaller than when jaggery of ordinary quality is made and unless a high price commensurate with the quality can be had, it does not pay to make it. Even as ordinarily made, the removal of the scum will mean a reduction of about two per cent in the outturn of jaggery, but where special care is taken for the very complete removal of the non-sugars, the reduction may be much higher. It must be noted that for a certain number of sweet preparations in Indian households, the ordinary quality is preferred on account of the high glucose content. A very high grade jaggery called " cream jaggery " is now being made, the filtration of the juice through " activated carbon " being the chief feature of the process; attention is also paid to all the points regarding the preparation of good jaggery described above.

The outturn of ordinary jaggery with local bullock-driven mills will vary from ten to twelve per cent on the cane, and from eighteen to twenty per cent on the juice. Varieties of cane and differences in methods of milling, and jaggery-making may lead to considerable differences in the outturn.

The milling of cane and the making of jaggery are usually carried on on a co-operative basis by a number of cultivators, by which method considerable expenditure is saved. Canes may be sold as standing crop to people who make a business of buying such crops as a speculation for conversion into jaggery and sale. Cane-milling and jaggery-making are let out on contract to professional people who go about in gangs with mills, pans and other equipment and buffaloes or bullocks and take up this work. Alternatively the work has to be done by paid labour, mills, pan, etc., being brought on hire for the season. The cost of making jaggery in this case may amount to five annas to six annas per maund of 25 lbs.

Yield.—The yield from sugarcane in South India is usually reckoned in terms of the jaggery obtained. The yield depends a great deal upon the method of cultivation, especially of manuring and irrigation, and upon the variety of canes planted. A good yield of jaggery may be put down at 300 mds. of 25 lbs. per acre, which will correspond to about 30 tons of cane per acre. The average yield however varies a great deal and is very much less than the above yield and may be taken as about 200 maunds corresponding to tonnage of about 20 tons an acre. With the heavier yielding varieties and with very large doses of manure comprising cattle manure, oil cakes and sulphate of ammonia,

much higher yields are obtained, and the tonnage of cane may go up to 45 tons per acre. It is however possible on the fertile clayey loam soils under perennial irrigation to increase the yields still further. Crops raised for prize competitions in Mysore have reached 70 tons an acre, and in Southern and Central Bombay, similar prize crops have reached even 104 tons per acre. These are raised on comparatively small areas and under exceptional conditions, but they at least demonstrate the possibilities. Under normal field conditions, a yield of 40 tons per acre may be taken as a high yield and 40 to 45 tons as a very high yield for canes which mature in about twelve months. In varieties whose period extends over eighteen months or more, extraordinarily high yields are possible with heavy manuring, regular irrigation and uninterrupted growth. Record yields of even 18·5 tons of sugar per acre are reported from Hawaii, which will correspond to 185 tons of cane per acre.

Sugar Making.

(*a*) *'Boora' Sugar.*—The making of white sugar is carried on in large scale sugar factories and the methods of manufacture are too elaborate to be described here. The student should however possess a general idea of the principles and to these reference will now be made. Indigenous sugar called "boora" sugar in South India used to be made from ancient times until recently, when the enormous import of cheap foreign sugar made the production of indigenous "boora" sugar quite unremunerative. In this process the cane juice was treated and boiled in the same way as for jaggery, but the boiling was stopped a little before the jaggery stage, and the thick syrup called Rab (or masscuite, in modern sugar making) was poured into earthenware pots and stored. The 'rab' cooled and crystallised in the pots and after this was complete, the next process of separating the crystals from the liquid portion or the molasses began. This was done by breaking the pots, removing the contents and packing them into large closely plaited wicker baskets placed on a frame work over large brickwork cisterns or tanks into which the molasses drained gradually. The separation of the molasses was facilitated by covering the top of the crystalline mass in the baskets with a thick layer of tank moss, the moisture in which trickled down through the mass carrying considerable dilute molasses and of course a little dissolved sugar with it into the tank below. The moss had a certain amount of bleaching action also. This was repeated for several days with a change of the moss every time until the sugar was pure enough. The crystalline sugar was then taken out, dissolved in water, and boiled as for jaggery, but in much smaller pans with the addition of milk every now and then which brought up the impurities; these were carefully and thoroughly removed by skimming.

At the 'strike' stage the pan was taken down and the mass as it cooled was rubbed down with wooden mallets into a fine powder, —the soft "Boora" sugar of the trade.

(*b*) *Refined Sugar.*—The manufacture of white sugar in modern factories is in two ways, *viz.*, (1) the making of refined sugar, (2) the making of "plantation white" or "direct consumption" sugar. The former deals with jaggery or raw sugar or refining crystals as the raw material and the latter has the cane itself as the raw material and the factory is therefore situated in close proximity to cane fields. The former may be situated in any manufacturing town in any part of the world where sugarcane itself may be unknown. The jaggery, raw sugar or refining crystals are made at the centre of cane production and are shipped to the refineries. Divested of manufacturing details, the processes in a refinery are (1) dissolving the jaggery in water and the removal of the impurities by filtration, (2) the decolourisation of the filtered solution by bone charcoal, by allowing the juice to percolate through bone charcoal packed in tall towers, (3) the evaporation of the juice and concentration by steam heating in vacuum pans, that is, under reduced pressure, and its conversion into "masscuite", (4) the separation of the sugar crystals in the masscuite from the molasses by centrifugals, (5) drying and crushing the sugar.

(*c*) *'Plantation' White Sugar.*—In a "plantation white" sugar factory the process includes the crushing of the cane in addition while the filtration through bone charcoal is dispensed with; there are however other arrangements for cleaning or decolourising the juice which are somewhat less thorough than in the refinery. The process divested of manufacturing details is briefly as below:—

(1) *The Extraction of the Juice.*—This is very thorough, the cane being passed successively through a series of three or four mills each of them having three rollers; sometimes the canes are first shredded or lightly crushed in a two roller crusher. After the crushed cane passes the first set of rollers it is 'macerated' or sprinkled over with water and then passed through the second set of rollers; the maceration is repeated at the next set of rollers and again in the following one also. (2) The straining of the juice and treatment with lime in "defecators" which are tall open tanks heated by steam and provided with gutters around the rim into which the "blanket" of scum is brushed. (3) Allowing the precipitate to settle and drawing out the clean juice. (4) 'Sulphuring'; passing sulphurdioxide through the juice to effect a certain amount of bleaching. (5) Evaporating and concentrating the juice in a series of three or four vacuum pans by steam heating under reduced pressure. (6) Further concentrating this syrup into masscuite of the proper consistency also by steam heat under reduced pressure in a separate vacuum pan. (7) Drawing the masscuite into cooling

tanks and further crystallising. (8) Centrifugalling the masscuite for separating the sugar with a slight washing by spraying water in the centrifugal and sometimes a little 'bluing' with a dye at the same time. (9) Drying the sugar with hot air in special dryers and crushing the sugar to remove lumps and reduce it to a uniform powder. A lower grade sugar is recovered from the molasses of the first centrifugalling which contains generally considerable sucrose dissolved in it. The scum from the defecating tanks is passed into filter presses and this juice is thus recovered and added to the juice at the third stage. The manufacture comprises a large number of working and mechanical details for which special works must be consulted. The above process is known as the "Sulphitation" method.

Another method is the "Carbonatation" single or double. This method avoids the 'Sulphuring' and instead comprises the liming of the fresh juice heavily to alkalinity, and precipitating all the impurities and then passing carbondioxide gas into the juice to precipitate the excess of lime. Later the impurities are eliminated by scum removal and settling, and the subsequent operations are essentially the same as in the sulphitation method.

The extraction of the juice from the cane is almost universally by the process of crushing the cane between rollers. There is however another method by which the juice can be extracted and which though universal in the case of the sugar beet has been adopted with sugar cane also to a very small extent. This process is called the "Diffusion" process. In this process the sugar cane is first sliced into very thin chips. The chips are packed into large receptacles where they are steamed and treated with water (or dilute cane juice). The cell walls are partially killed by the heat, and the sugar juice inside the cell diffuses into the water by "osmosis". With fresh charges of water, the sugar in the juice is progressively depleted, until finally the chips are completely deprived of the sugar, and are rendered fit only for fuel. After the extraction of the juice, subsequent treatments are in principle similar to the other processes.

By-products.—The by-products in the manufacture of sugar are converted into many valuable articles of commerce, of which the following may be mentioned. The begasse or the refuse of the cane after the juice is crushed out is made use of for the production of paper, artificial silk, fibre boards (Celotax and Vazcane), feeding stuffs and charcoal. The molasses are made use of for the making of rum, power alcohol, dry ice (solid carbondioxide), yeast, cattle feeds, road surfacing and for fertilisers. From the filter press cake is extracted the sugarcane wax, which is used for the making of shoe polishes, and in the candle making and sealing wax industries.

From the cane field itself great quantities of green cane tops and leaves are obtained when the cane is being harvested. These leaves and tops form valuable green fodder, which is fed to the

cattle on the spot but can be dried and stacked or converted into silage with other green fodder. The cane trash, that is, the old and dried leaves of the cane which are stripped when trimming the cane at harvest, also accumulates in enormous quantities. While the most common way of disposing of this material is by burning it in the field, it can be made into a compost manure, which can be used later for the sugar cane crop itself or for other crops. One method—the Indore method—of making this compost is the following :—

Cane Trash Compost.—On account of its texture and of its deficiency in nitrogen and soluble material, cane trash has to be mixed with considerable green vegetation, such as grass and weeds to make it decompose properly. The best way of adding this green material is to sandwich it between layers of trash, after moistening the former with a slurry made by stirring up cowdung in water in the proportion of 7·2 parts of fresh cowdung for every 100 parts by weight of green material along with three parts of wood ashes and five parts of earth. It may be also necessary to add both lime and bone-meal to the heap at the rate of half part of unburnt lime and five parts of bone-meal per 100 parts of the green material. Heaps eight feet in width and three feet in height and with length depending upon the quantity of trash available are made, the bottom consisting of a 4" layer of trash then alternating with 1½" layers of green material and ending with a layer of trash on top. In a few days after the heap is piled, it is broken and remade as before with further addition of small quantities of green stuff. Where green material is difficult to get, some sannhemp seed can be strewn on the heap. The growth of these plants in the course of three weeks will furnish sufficient material for addition at the next breaking up and remaking of the heap.

Pests and Diseases.—The insect pests of sugarcane in South India that are of any serious importance are the following :— (1) The moth borers of different kinds, *viz., Argyria sticticraspsis H, Diatræa, W, and Scirpophaga nivella, F.* These comprise borers which attack the primary shoot of the young cane and cause the "dead hearts", which attack the top shoots of the half-grown and even maturing canes and those which attack the stems of the canes and bore into them. Of these the first is really the most serious. The moth lays a group of eggs on the young leaves from which the larvæ emerge and crawl down into the shoot, cut the base of the shoot, bore through and pass into other shoots if available, and continue the damage until they pupate. The egg masses can be readily detected if looked for and one remedial measure consists in rubbing them off. The moths after emergence have the tendency to hide and rest under the shade and protection of any rubbish heap on the ground; this habit is taken advantage of to destroy them by laying little heaps of cane trash here and there in the field as traps for the

moths; they are attracted to the shade and protection of these heaps where they can be caught and destroyed. The cutting out of the "dead hearts" in good time and the earthing up of the cane with a country plough at this stage have already been referred to as other remedial measures.

An efficient method for large scale application is the "biological" method of setting free parasites of the borer moth. The egg masses of this moth are heavily parasitised by the parasitic wasps,—*Trichogramma sp.*—which therefore effectively check the pest. The *Trichogramma* parasites are bred artificially on the egg masses of the moth destroying rice and jola. The eggs of the parasite are kept in cold storage. When required they are taken out of the cold storage as and the wasps emerge they are released in the cane field, where they parasitise the eggs of the borer moth and thereby keep the pest under control.

The other borers are of comparatively of minor importance. The top shoot borer causes damage by making the canes send out side shoots from near the top nodes and thereby reduces the quality of the cane. The borer pest often gains entrance into the crop through affected seed sets; if care is exercised in selecting only healthy seed sets, considerable relief can be secured.

(2) Canes are sometimes badly affected with the mealy bugs—*Trionymus sacchari, G.* These cluster in large numbers in the internodes round at the base of the leaf sheaths, by which they are well protected, suck the sap and weaken the cane. This pest is probably incidental to cane weakened by want of sufficient irrigation or rainfall or manuring; it is said to favour ratoon cane, but plant canes are also heavily infected. The damage however is not serious.

(3) Cockchafer grubs in certain places cause a great deal of damage by gnawing off the lower portion of the cane and destroying the young clumps, and causing many bare patches in the cane field. Arsenical baits have been tried but not with much effect. 'Neem' oilcake has been tried as a repellent with not satisfactory results. Digging out the grubs at the very first appearance and preventing an extension of the pest is about the only satisfactory remedy.

(4) The omnivorous white ant is one of the destructive troubles of the sugarcane firstly at the germinating stage and later on when cane begins to suffer from lack of sufficient irrigation. The use of repellents, the stimulation of growth in the younger stages by quick acting manures like ammonium sulphtate, heavy irrigation when possible, removal of white ant hills together with the queen ants in the nests, and keeping the field free from dry sticks, leaves, etc., which may attract white ants are some of the remedial measures which have already been partly alluded to in connection with the care of the seed sets.

(5) An insect pest that has become very serious in recent years especially in Upper India is the 'pyrilla hopper'—*Pyrilla perpusilla*, *W.* This is an active straw-coloured bug which is found in all stages on the leaves of affected canes in very large numbers; they suck the juice of the leaves and reduce them to a dry and shrivelled condition. The growth of the cane is seriously affected and the damage and reduction in yield are both great. The egg masses are found as fluffy lumps on the underside of the leaves, and hatch into innumerable hoppers. The life cycle is only two months so that several broods may appear on the canes during the season. There are no satisfactory remedies known. The insect is kept somewhat under control by natural parasites. The leaves can be sprayed with contact poison, but this is not always practicable. The removal of the lower leaves and keeping the stem clean has been found to reduce the pest. Moreover some varieties are immune or almost immune to the attack of the pyrilla and if otherwise suitable, these will have to be planted in preference to the susceptible ones.

The diseases of cane due to fungoid, bacterial, virus or physiological causes are many and one of them at least, *viz.*, the "red rot" disease should be classed as a serious one in South India.

(*a*) The "red rot" is caused by the fungus *Colletotrichum falcatum* and is recognised by the red colouration which is noticed in the interior of the cane when it is split open. The wilting and the slow drying up of the leaves and then of the cane itself, with a shrunken appearance and a lack of rigidity and a drying up of whole clumps in the same way even though there may be plenty of moisture in the ground are outward signs in an attacked field. The red colouration becomes more intense and spreads over large areas of the interior of the cane; simultaneously spores are formed and are scattered from the rind at the nodes and from dried up leaves and leaf sheaths. The loss due to the disease is firstly a reduction in the tonnage of the cane consequent on the drying up of many clumps or individual canes and secondly a deterioration of the quality of the juice and difficulty in making the jaggery set properly, owing to the fact that many canes which are partially or wholly attacked are included in the milling.

The disease can be controlled only by strict attention to the nature of the seed sets planted which should not only be devoid of any red colouration giving cause to suspicion but should be cut from canes and clumps which are free from the disease. Infection through soil is also possible; and this may be largely prevented by a suitable crop rotation, by shutting out water flowing from infected fields, by preventing damage to cane by vermin and thereby shutting out the means of entrance to the fungus. Lack of drainage is a predisposing cause and increases the susceptibility of the canes. Varieties too differ in

their resistance to the disease, and the soft local canes like 'patta-patti,' and 'rasdali' are much subject to it, whereas the harder foreign canes and many of the seedling canes are fairly resistant.

(*b*) Another disease also characterised by a discolouration of the interior of the cane is the "pine apple" disease caused by the fungus—*Thielaviopsis paradoxa*. The interior of the affected cane develops hollows along the length which also turns dark coloured to sooty black, this being the colour of the spores. Characteristic of the disease is the fruity smell, resembling that of the ripe pine apple, which the diseased canes emit. The disease gains access to the cane through wounds and, in the seed sets, through the open ends of the cut canes. The disease is however of only minor importance in India. It is the same disease known as the bleeding disease of the areca, and of cocoanuts, to which reference is made under these crops.

(*c*) Cane Smut.—(*Ustilago sacchari*) is another disease of some importance and is particularly severe on the thin cane "cheni" in Mysore and is also found on other varieties of the seedling canes. The disease is characterised by the growing shoot of the the cane being converted into a sooty black whiplike growth, from which a cloud of black dust—being the spores of the disease—can be shaken down. Infection is through the presence of the mycelium in the cane sets planted, through the spores gaining admission through cut ends, wounds, bud hairs, etc. The affected canes can be seen in large numbers especially in the younger canes generally in the primaries; the damage does not amount to much, as the canes often make up by a somewhat free tillering. Smut is seen in older canes also but not on such a scale as to affect the yields materially.

(*d*) The "mosaic" disease of cane has become somewhat serious in recent years especially after the large number of varieties of seedling canes came into cultivation, though perhaps in a less conspicuous form it may have existed in the country even before. The outward characteristic of the disease is a mottling of the leaves produced by white blotches and streaks on the green background of the leaves. The loss due to the disease arises from a general weakening of the growth of the canes, a stunted growth being a prominent feature. The effect of the disease is therefore a material reduction in tonnage. The composition of the juice does not seem to suffer and affect the quality of the jaggery, except when the disease is in a very advanced stage. Control measures are the following;—

1. The planting of cane sets taken only from mosaic-free clumps.

2. The removal of clumps as soon as the mosaic appears. Marked success has been found to result by these methods in stamping out "mosaic" in tracts where it was much prevalent.

Varieties also differ in their susceptibility to the disease. The results of a trial of the varieties comprising a large number

of seedling canes showed great variation in susceptibility; four of them showed complete freedom from infection while some others were at the other extreme and became fully infected, while others again showed varying intermediate degrees of infection. It may be possible in many places therefore to replace the susceptible canes by those showing a high degree of resistance, if these should be otherwise suitable also.

Many of the seedling cane varieties suffer from an abnormality in growth, in which the canes do not make any growth in height but spend themselves in sending up a large number of tillers. The clumps resemble large rosette-like bushes which seldom grow more than three or four feet in height; only one or two shoots develop in height and show regular cane formation while the others remain dwarfed, like a clump of giant grass. Sometimes a very large number of clumps in the rows may remain in this condition causing a serious reduction in the tonnage of cane. It is not known if the abnormality is due to any disease, such as "sereh" in Java, in which a very similar dwarfed growth of cane is a marked symptom.

Vegetable Parasites.—A troublesome vegetable parasite of the sugarcane is the *Striga.* The roots of the striga plant twine themselves with the roots of the cane and partially drain the nourishment from the cane. The result is a weakening of the cane and poor growth. The striga grows as a parasite in this manner on jola, and its seeds lie dormant in the ground for many years and are capable of sprouting and growing when the appropriate host crop is sown in the field. No effective remedies are known and the only way to keep it down is to weed out the pest as soon as it appears, root and branch, systematically, taking special care further to remove the plants completely before they flower or at any rate before they set seed. Continuous weeding is necessary, as the plants spring up from broken underground stems if the weeding had not been deep and thorough. Chemical weed killers like sulphate of iron and other materials are sometimes suggested, but for effective control they become too expensive and not practical. Where sugarcane is grown in rotation with rice or a rice crop is grown occasionally in the course of three or four years, the 'striga' seeds along with the seeds and roots of other weeds troublesome in garden cultivation are killed out to a great extent by the continuous flooding of the field necessary for rice cultivation.

Other vegetable parasites which are however confined only to certain tracts and are not of a serious character, are the *Aeginetia paniculata* and *Aeginetia pedunculata,* reported from Burma and Bengal, respectively.

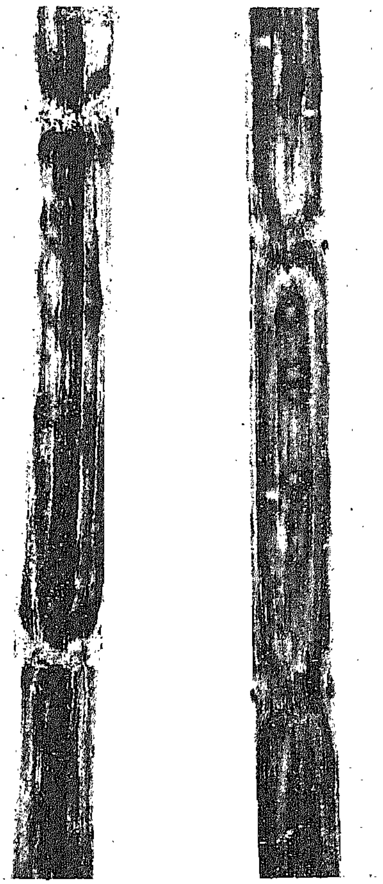
Production and Trade.—The sugarcane crop of India was being made use of for the production of both jaggery and indigenous sugar to meet the needs of the country for centuries past. It was only some fifty years ago that cheap foreign sugar

began to be imported in large quantities and the taste for sugar in preference to jaggery began to grow and sugar began to be imported in ever increasing quantities. The import of subsidy-fed beet sugar from Europe and of cheap cane sugar from Java where large scale production aided by efficient scientific research greatly reduced the cost of production, ruined the sugar industry in India which dwindled into insignificance. Stray refineries and sugar factories were just able to carry on only because they ran also distilleries as adjuncts for a profitable utilisation of the molasses and poor grades of jaggery. The huge import of sugar is the most conspicuous feature of the trade of India in this period. Thus in 1893-94, it was 106,000 tons; five years later it rose to 204,000 tons, and in another five years to 290,000 tons. The cane crop of India could be utilised for only the making of jaggery and the efforts of industrialists, large land owners and Government to divert the crop for the manufacture of sugar were fruitless, until a drastic change took place in the fiscal policy of the Government and a substantial protection was afforded to the industry by the imposition of a protective duty of Rs. 9-1-0 per cwt.

This was in the year 1931-32. The effect was marvellous and quick and surpassed all expectations. Sugar factories of up-to-date design have been started in large numbers and have been working so successfully that the imports have steadily declined and are now insignificant. Within a brief period of five years, the local production has increased from almost nothing to the stupendous figure of 1,111,400 tons (1936-37) and ousted foreign sugar almost completely. Thus while foreign sugar was imported to the value of Rs. 27½ crores in 1921-22, in the year 1935-36, it came down to Rs. 1·85 lakhs. Indeed the production bids fair to outgrow the internal demand for sugar and the question of finding a market for this sugar has now become a serious problem. All this increase is in spite of the fact that Government imposed an excise duty of Rs. 2 a cwt., on all sugar manufactured in the country and to that extent neutralised the advantage of the protective duty on foreign sugar. It must be added that an auxiliary factor of great importance in this change is the introduction of the new seedling varieties of cane which are far superior to the old local varieties and have all but displaced them from cultivation.

The following figures will give some idea of the progress of the sugar industry in India during this recent period.

Year	Number of sugar-cane factories	Production in tons.
1926-27	25	62,941
1931-32	32	158,581
1932-33	57	290,177
1933-34	112	453,965
1934-35	130	578,115
1935-36	137	912,100



Red Rot of Sugarcane.

Fig. i., A portion of *cane (split longitudinally)* showing typical 'red rot' blotches and characteristic white bands.

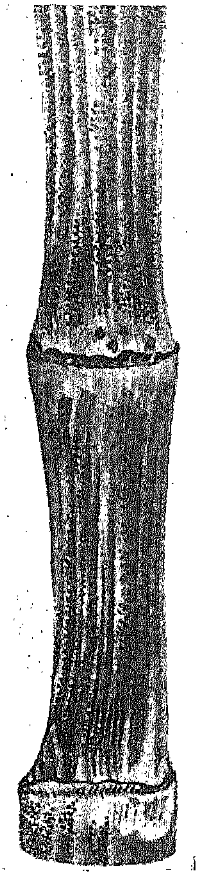
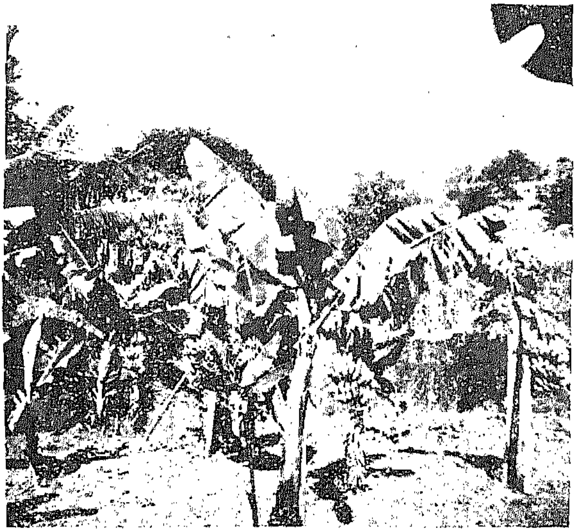


Fig. 2. A portion of cane showing advanced stage of Red Rot.

From 'Indian Farming', by courtesy of the Imperial Council of Agricultural Research.



Field of 'Gujju' bale, Mauritius or Dwarf Plantain.
[Photo by Author.

The cane crop of India is, however used in the main for the manufacture of jaggery. The total production of sugar in India, including sugars of all kinds is about 1,179,000 tons, but the quantity of jaggery produced is about six times this figure, *viz.*, about 6,717,000 tons. It is estimated that 65 per cent of the cane crop is used for making jaggery, 18 per cent for factory sugar and the remainder for 'khandasari' sugar, chewing and for seed.

The total area under sugarcane in India is about 4·4 million acres. The area under sugarcane in the chief cane growing provinces is as below:—Punjab about 510,000, U.P. 2,181 000 Bihar 360,000, Bengal 290,000, Madras 97,000, Bombay 70 000, Mysore 50,000, Hyderabad 31,000 and North-West Provinces 70,000 acres. (1937—38)

SECTION V.

MISCELLANEOUS FOOD CROPS.

I. THE PLANTAIN.

VERNACULAR NAMES FOR PLANTAIN :—KANNADA—*Bale* ; TAMIL—*Vazhai*; TELUGU—*Aranti*; MALAYALAM—*Vazha* ; HINDUSTANI—*Kela*.

The plantain forms one of the most important fruit and vegetable crops of India. Plantains are extensively cultivated both on a small scale as a back garden crop in practically every household in South India, as a field crop on a large scale and even as a plantation crop on a still larger scale on the hills. It is the one kind of fruit which is available everywhere even in the pettiest and remote villages and at all times of the year. It may be called the universal fruit crop of India, eaten by the rich and poor and available in great abundance everywhere and at all times. The plantain is a tropical crop par excellence. It is probably the most striking vegetation in the tropics and impresses one by its shape, the colour and gorgeous beauty of its leaves, the large and highly ornamental flowers and fruit bunches more than any other crop. The tropical belt in the continents of Asia and South America is held to be the home of the plantain from where it has spread to other parts of the tropical and sub-tropical world. Though it is only in the tropics that the plantain luxuriates under proper conditions of climate and rainfall, the crop can be grown up to the 30th parallel of latitude north as the northernmost limit while in the south also it can extend down to Lat. 30. In addition to India, the whole of the East Indian Archipelago, Malaya, the islands of the Pacific Ocean, Indo-China, and even Japan, Egypt, Natal, East Africa, the Canary Islands, the West Indies, Central America, the Guianas, and parts of South America as far as southern Brazil, Queensland and South Australia are all countries where the plantain and its allied species are found under cultivation. They are likewise adapted to growing under varying altitudes from sea level up to 5,000 feet and sometimes even higher, though under these conditions the bearing is delayed and the yield low. Plantains flourish under the damp and wet conditions of the tropics and can stand very heavy rainfall up to even 100 inches. It is indeed one of the important cultivated crops in the heavy rainfall tracts like the malnads of Mysore. The crop uses up very large quantities of water and abundant moisture is therefore necessary in the soil either through ample and well-regulated rainfall throughout the year as occurs in the

tropics proper or by heavy irrigation during the rainless months. The crop is also favoured by proximity to the sea, and is at its best in island climates and in coastal districts, though it can be cultivated several hundred miles inland also.

Soils.—Plantains are grown and do well on a variety of soils. The most astonishingly luxuriant growth is seen on the deep black clayey tank silt soils on the beds of old breached tanks which are rich with fine silt, the remains of water vegetation and of aquatic animal life, accumulated for several years. At the other extreme they are seen to grow equally luxuriantly on the sandy soils of the coastal towns provided they are heavily manured with coarse organic manures like cattle manure, city sweepings and refuse. Many types of soils of an intermediate character are also utilised largely. The clayey loams of which most rice flats are composed are some of the commonest soils on which plantains are grown ; on many heavy black cotton soils which are very retentive of moisture, plantains can be grown even as a dry crop. On the hill sides where the plantains are grown without irrigation and on a plantation scale, the soils are mostly of the reddish clay loam types. On the same types of soils but with ample irrigation are grown the special plantain, 'Nendrum' of Malabar. Fertility due to a large admixture of organic debris and wastes is what suits the growth of plantains most. Grown on a field scale, great attention is paid to the provision of adequate drainage which is very essential. In fact surface irrigation is even avoided and only sub-irrigation in deep trenches surrounding the plants is practised with a view to guarding against bad drainage and waterlogging. With provision for drainage even somewhat alkaline stretches of soil can be seen to be under plantains, though the plants are generally poor in growth and the leaves often become scorched. In the malnad gardens and in Malabar where the South West monsoon rainfall is very heavy, special attention has to be paid to the provision of good drains to carry off the rain water.

Except on the hills and in special situations where sufficient underground moisture is available and in certain black cotton soil tracts with good rainfall, plantains have to be grown under irrigation. A satisfactory irrigation source is therefore indispensable, and gardens are made only where tank or channel irrigation can be had throughout the year and especially in the hot weather. They are also grown under well-irrigation but only in comparatively small areas.

The plantain crop requires special protection against high winds. During the South-West monsoon when high winds blow, there is great danger of many plantain stems being blown down and broken. In many places this happens to be the time when the plantain bunches have appeared and the fruits are ripening, making the stems very top heavy and liable to be easily brought down by the wind. In the littoral of the cyclones on the eas

coast the danger of extensive damage is very great. The situation selected for plantains should preferably be somewhat sheltered naturally and in every case a good tall hedge which can act as a windbreak quite as much as a fence to keep off thieves and stray cattle will have to be provided. As an additional precaution bamboo props will have to be provided for each plantain stem and especially so if the trees should be heavy with fruit bunches during the windy season. This sort of damage is not so greatly to be feared or guarded against in the case of the mixed gardens of plantains, cocoanuts and arecanuts or of mango, jack and guava and other fruit trees in addition, which are very common, nor in the case of the dwarf variety, called Mauritius, which is being largely grown in recent years.

Rotation.—Plantains are grown either by themselves as a pure plantain garden or as a mixed subordinate crop in areca gardens or in fruit gardens containing a variety of fruit trees like, mango, jack, cocoanut and so on. The pure plantain gardens are grown either as part of the ordinary rotation on rice fields when they are allowed to crop for one, two or three seasons and then removed or they form almost permanent plantations as on the hills where they occupy the ground for several years and are removed only when the plantation becomes spent out and the crops are no longer good enough to be profitable. In the mixed plantain gardens, the plantains may form merely a nurse crop as in the case of cocoanut gardens and may occupy the ground for some four or five years, during which period they shade the young cocoanut plants, keep the garden cool, keep down weeds and afford at the same time a small money return. There is also a belief that the plantains keep off the rhinoceros beetle from the cocoanut plants at this stage, although this is not well founded and should in no case be regarded as a substitute for careful watching and removal of beetles from attacked plants and for other methods of control.

Planting Material.—The plantain is propagated vegetatively and the planting material used is the sucker. The suckers used are either very young ones hardly a foot or two in height, or older ones which are three or four months old and which have grown well. In the case of the very young suckers, those which have the long narrow so-called 'sword' leaves are preferred to the broad-leaved suckers, as the former root more readily. Suckers intended for planting are removed with a good portion of the rhizome; the cut surface should be examined for signs of weevil attack and if any are seen, such suckers should be rejected. The roots of the sound ones and the top one-third of the length are also cut away. The suckers are allowed to dry and harden for some days. Suckers can be kept quite for a month after removal and then planted. The larger and older suckers are preferable to the smaller ones, as casualties are high in the latter. Large rhizomes can also be cut into several pieces and planted in a

nursery and when the plants are grown to a height of two or three feet they can be planted out.

Cultivation.—The field intended for plantains should be prepared thoroughly and carefully quite six weeks before the planting is to be made. The field is either ploughed several times or is dug uniformly to a depth of nine inches. The soil is allowed to weather and the clods are then broken and weeds and stubble removed and burnt. The field is also manured by the penning of sheep and the soil then lightly ploughed. Pits for the suckers are now dug about 7½ feet to 9 feet each way, about a foot square and about 18 inches in depth. The pits are filled with the weathered soil and mixed with a good basketful of cattle manure which may work up to about 30 or 40 cart-loads per acre. Suckers are planted in these pits quite deep and the soil around them is well tamped by trampling with the feet or rammed with a heavy stick. Beds for irrigation are now made so as to enclose each of the 600 to 800 plants that go to the acre at the above planting distances. Once every week a heavy irrigation is given; on the retentive clayey soils irrigation is less frequent and can be given once in ten or twelve days, though they can stand a break of even three weeks. The beds are weeded frequently and at the third month are given a digging. At the same time oilcake powder (groundnut, castor or neem) is applied at the rate of 10 to 15 cwts. per acre. A mixture of artificial manures consisting of 2 cwts. of sulphate of ammonia and 3 cwts. of superphosphate can also be applied at this time in the case of the red loamy soils with benefit. Irrigations are now given regularly at intervals of not less than fifteen days right up to the time that the bunches are ready to harvest.

When the plantains are grown in the midst of rice fields or when the soil is clayey and requires considerable drainage, drains have to be provided. These are dug after the plants are about a month old in such a way that four plants are enclosed by drains all round, by digging lengthwise and crosswise drains after every two rows of plants. The earth from the drains is thrown up on to the beds around the plants, so that the beds each with four plants in it become quite elevated and are surrounded by the drainage channels. These channels serve as irrigation channels also from that time. No surface flow on the beds is necessary except in the hot summer months when the drains may be blocked and water made to flow over the beds. After every such surface flow the beds are given a digging, to keep the surface soil loose.

In addition to the digging, manuring and irrigation during the growing period, other operations consist in the trimming of the dry leaves and the removal of the sucker growths from the parent stem. In all careful cultivation such suckers should invariably be removed as they come up, in order to divert all the

nourishment to the parent stem and the fruit bunch thereon. When the inflorescence is seen to be pushing out, then the cutting out of suckers is stopped and one good sucker is allowed to stand and grow; from this sucker special care is taken to see that no leaves are cut. This sucker forms the main or bearing stem for the second year's crop. The same routine is followed in regard to sucker removal in the third year's crop also.

Period from planting to fruiting.—The time taken from planting to the appearance of the inflorescence varies a great deal with the varieties from about 8 months to even 18 months. The season of planting influences this period of time even in the same variety. The varieties commonly grown in South India such as the 'Poovan' and the 'Rasabale' take about 8 or 9 months. January plantings flower later than June plantings and the difference in time may go up to even three months, though two months is common. The length of time from the appearance of the inflorescence to the stage when the bunch can be cut down for yellowing or for sale is subject to great variation between one variety and another. It has been observed that the early varieties in South India take from 80 to 110 days for such maturity, that the late varieties take from 150 to 170 days and that medium varieties take from 120 to 150 days. The commonly grown field varieties 'poovan' and 'rasabale' take about 7 to 8 months to flower and another two to two and a half months to mature.

As the fruits are ripening on the plants, there is a tendency in some varieties for the fruits to split or crack, due it is believed to exposure to the sun and want of sufficient shade. Where this tendency is common the bunches will have to be protected by being tied over and covered with dry leaves. At about this stage the danger of the stems breaking on account of the weight of the bunches is also great, and the props which may have already been provided as a protection against damage by wind should be attended to and strengthened. Another little routine to be attended to is the removal of the 'buds' from the bunches. After the pistillate flowers have all set fruit, *i.e.*, after the bunch has been fully formed, it is desirable that the "bud" containing the remaining flowers should be broken off and removed. This leads to greater uniformity in the development of the fruit and to a shortening in the period of maturity.

Stage to cut the bunches.—The bunches are ready to cut when the raw green of the fruit begins to get lighter, the fruits swell and the ridges become less prominent or almost rounded and the fruits give a characteristic sound when hit with the knuckle. A fruit or two showing a decidedly yellow colour is of course the surest sign, but it may not always be advisable to wait till this rather late stage. The variety called 'green' plantains has to be judged entirely by indications other than yellowing. The cooking plantains are cut at an earlier stage

although even these are cut quite ripe and often have to be prevented from yellowing and developing sweetness by being left in cold water, if it has to be kept for a few days before being used. The bunches are cut with a good length of the stout gooseneck stalk and are transported, handled and marketed with this stalk intact almost invariably. After the bunches are harvested, the stem (the plant) is cut down to the base and all further attention is paid to the sucker which has been left standing and which becomes the bearing stem for the second year's crop; a like procedure is adopted with the latter at the end of the second year.

Yield.—Each plantain sucker planted gives one bunch and the number of bunches per acre amounts to from 600 to 800 according to the number of suckers planted. The number of fruits in a bunch and the size of the fruits therein, in one and the same variety, depends upon the thoroughness of the cultivation, soil, manuring, and irrigation. With the second and third crop the size becomes reduced and the bunches fetch a smaller price. As between varieties the number of fruits and their size, as indeed many other characters, vary a great deal. Varieties with large fruits generally have a much smaller number of fruits per bunch than those with smaller fruits. There are however exceptions; thus the 'rasabale' of Mysore which is a choice table variety has only a small number of fruits in the bunch though the fruits too are small. The plantain fruits are, as is well known, borne in groups of 'hands' which make up the bunch. The number of hands generally varies from four or five as a minimum to as many as 40 or 50 as a maximum in a specially small fruited variety and in the bulk of the varieties the average may be taken as seven with ten as a high figure. The number of fruits per hand likewise varies a good deal though by no means to the same extent.

Ripening.—The ripening of the fruit to the yellow, sweet, eating stage is allowed to take place invariably after the bunch is cut. Fruit is never allowed to ripen on the plant itself completely. The ripening takes place by merely keeping the bunches hung in well ventilated rooms when in the course of a few days the fruits ripen uniformly, every one of them developing the colour, consistency and taste of the ripe fruit, or ripen irregularly, so that when some are yellow others are only partially so or even green in colour. In order to attain uniformity in colouring, it is sometimes usual to artificially stimulate the colouring and ripening by subjecting the bunches to the dull damp heat of a smoky fire. For this purpose the bunches are arranged in a low cellar like room which is provided with an opening for a fire and a vent for the escape of smoke. A slow burning fire is made at the entrance by lighting up dry plantain leaves which are well packed and which smoulder slowly. The smoke fills the chamber and escapes through the vent and the

interior of the cellar also becomes heated. After sometime the fire is put out and the vents are closed. The cellar is kept closed for a couple of days and then opened and those bunches which are all coloured a full yellow by this time are taken out. The bunches which are still incomplete in colouring are subjected to the same process again to complete the colouring The process is a rough and ready variation of the process of colouring citrus and other fruits by ethylene, carbon monoxide and such other gases.

Botany and varieties.—The plantain—Musa paradisica—belongs to the order Scitamineae, to which several other important agricultural crops like turmeric, ginger and cardamoms belong. It is classed under the family or tribe Musaceae. The edible plantains include also another species, 'Musa sapientum' sometimes called banana. The terms banana and plantain are used more or less synonymously but 'plantain' is often restricted to the kinds whose fruits are eaten fresh as soon as they are ripe, as distinguished from those which have to be often cooked by boiling or baking before they are eaten, even though they are quite ripe. The plantains and bananas, the genus 'Musa' in fact, comprise plants which are large and tree-like with the leaf canopy borne on a tall unbranched smooth cylindrical stem or trunk. This stem, which is only a pseudo-stem, is made up of the thick highly succulent convolute sheaths of the leaves which extend from the underground rhizome or true stem to the stalk or petiole from where the leaves lean away from the stem. These leaf sheaths form concentric layers giving in their combined form the cylindrical trunk-like appearance to the stem, and protecting the younger leaves and flowering stalk which form the core of the stem. The true stem is an underground rhizome or bulb from which the false stem grows and which also gives rise to more stems or suckers. These suckers are few and appear at long intervals in some varieties but in other varieties appear in larger numbers and at frequent intervals giving rise to very large clumps. From the rhizomes spring the roots both vertically downwards and laterally and horizontally. The clumps are on the whole shallow-rooted especially when the above ground parts of the plant are considered, and the roots traverse a depth of two or three feet with about the same lateral spread. The anchorage is hardly adequate and where the additional strength given by suckers is lacking, proves still less so. The leaves consisting of the stalk and the blade may vary from 10 to 20 in number and the leaf blade which is large and oblong may be from 6 to 10 feet long and 1 to 2 feet broad. The colour is dark to light green, the texture thick and leathery to thin, with often a whitish bloom on the under surface; the midrib is either yellow, light yellow or cream coloured, or with a dash of purple, and with or without a pronounced ashy white bloom on them. The lamella of the leaf

though graceful and entire when it opens, soon becomes more or less torn into shreds by the wind. The inflorescence which is a spathe emerges from the top in the shape of a large bud and in a few days as it lengthens curves and bends down in the familiar pendent form. The flowers are borne in a series of clusters on the flowering stalk, to which when they set fruit the name 'hands' is given. At the base of each cluster is a large scoop like bract which tightly shuts up and protects the cluster before the flowers are due to open but which later on opens and exposes the flowers and then drop off. These bracts are small, large or medium in size; are coarse and thick or thin and delicate in texture and are deep red, light red, salmon or pink in colour according to the variety. The individual flowers at the basal hands are all pistillate and set fruit, parthenogenically, it is generally held; the ovary is three-celled but the ovules do not develop or set seed. The stamens are five in number (rarely also six). The floral parts are much modified. The perianth consists of three sepals which are fused into two rudimentary petals. The third and separate petal is a thin papery cup-shaped structure in which is secreted a kind of sweet nectarlike thin jelly. Though all the flowers are perfect only the lower flowers are functionally pistillate and set fruit. Some four to ten or twelve clusters or hands according to variety have such pistillate flowers; the flowers in the succeeding clusters are either neuter or staminate functionally. The pistillate flowers set fruit, and the ovaries swell into the fruit; the ovules do not develop in the cultivated varieties and no seeds form, except in rare cases when a small seed or two may be found.

The cultivated varieties of the plantain are many but not so large in number as the names in different countries or provinces would appear to indicate, as one and the same variety is known by different names in different places. Rather marked changes in size and quality of fruit are also brought about by differences in soil, climate and cultivation. Varieties differ in the height and size of their trunks, in the texture, size and appearance of the leaves, in the period they take to mature fruit, in their susceptibility to diseases and pests and above all in the size, shape and colour of the fruit and in the taste, consistency and other characters of the flesh inside. Several good varieties are grown in the Mysore State and from the following description it will be seen that many of them are the same as those that may be grown in other parts of the country, though under different names. Some of the main varieties in Mysore and their characteristics are as below:—

The 'Maduranga bale' is the large cooking plantain with fruits about 6 to 9 inches in length and about three inches across at the widest, with the ridge conspicuous, a thick green skin which becomes yellow when the fruit ripens and which can be peeled in two layers; the pulp or flesh is yellowish white,

very soft, pulpy and sweet. The bunches contain only a small number of fruits seldom exceeding fifty but averaging about thirty. Closely similar to it is the field plantain which is also a cooking variety; the fruits are shorter and the ridges more rounded. The bunches carry a larger number of fruits. The 'Maduranga bale' is subject to a fungus disease which attacks the stem and makes it fall over and rot, before or at the time of the appearance of the inflorescence.

The "Rasabale" is a choice table plantain, has a golden yellow colour when ripe, the skin is very thin and the pulp firm. It has a sweet taste with a special flavour and is esteemed as a wholesome light food as distinguished from the heavy feeling engendered by eating other varieties, The fruits are about 3 to 4 inches in length and about 1½ inches across. The bunches are never large and contain four to five hands with eight to ten fruits each. The skin is liable to split when the fruit is quite ripe. The fruit keeps well for some days and the flesh remains firm. This variety is also badly subject to the fungus disease in which the stem begins to rot and fall over. A very similar but somewhat larger sized fruit is called "Salem Rasabale". It is less delicate and is not so much esteemed.

The Gulur plantain is a tall vigorous variety, the fruits are about 4 to 5 inches long and about 1½ inches across, with the ridges showing well, slightly curved with a bright yellow skin which peels off in two layers. The fruit is sweet and the flesh moderately firm. On keeping, the flesh softens considerably. The bunches are very large and well filled and may carry as many as 100 or more fruits. It is a hardy variety and the suckers are very vigorous, so that the clumps may be allowed to crop for several years.

The 'yelakki' plantain is a somewhat delicate looking, tall plant with comparatively thin leaf sheaths and stalks whose margins are flushed pink. The fruits are small, about 2½ to 3 inches long and 1 to 1½ inches across the middle, the ridges are somewhat rounded, the skin is very thin and papery, peeling off in a single layer, the flesh is very firm and keeps so for many days even though the skin may shrink and blacken. The fruits are very sweet and the bunches large.

The 'rajabale' is a sweet variety somewhat showy; the skin is thick and light green turning but slowly into a light yellow. The fruit has a somewhat peculiar shape, with a smooth tapering beak. The fruits are about 4 or 5 inches in length and 1½ inches across. The flesh is sweet but is very soft, and when very ripe almost like jam. The skin is liable to split and the fruit cannot keep well. The bunches are medium, somewhat open and may carry about 50 or 60 fruits.

The 'Boodhibale' or 'ash' plantain is a tall vigorous plant with large bunches which may carry up to 100 fruits. The fruits are 4 to 5 inches long and about 1½ to 2 inches across.

The unripe fruits have an ashy bloom over them which is characteristic and to which it owes its local name. The skin is thick, peels off in two layers and the flesh is very soft and does not keep well. The fruit is only moderately sweet.

The 'Havu bale' is also a vigorous variety. The fruits are about 6 to 7 inches long and about 1½ inches across, slightly curved, the ridges smooth and almost rounded, and having almost a uniform thickness up to the tip, so that there is no pronounced beak. The fruit colours yellow when ripe but soon becomes spotted and blotchy with black or brown. The skin is thick and the flesh soft. The bunches are very large and may carry up to 120 fruits.

The 'kari bale' also called 'mara bale' and 'male bale' is a hardy plantain which grows largely in the malnads in the hilly country with heavy rainfall both in the areca gardens and on the hillsides and the coffee estates. It is vigorous and hardy, with the leaf sheath margins a dull black in colour. The bunches are medium in size carrying about 50 or 60 fruits. The fruits are about 4 to 5 inches in length and the ridges are conspicuous; the skin is thick and yellowish in colour often with a slight bloom on it but becoming black or blotched very soon. The flesh is firm when the fruit is fresh but on keeping softens considerably and unevenly. The fruit has a peculiar flavour which is much esteemed in South India. The 'male' plantain of South India is very similar to this variety in size, shape and flavour but keeps longer and stands considerable transport.

The 'poovan', which is largely grown on a field scale as a rotation crop with rice in South India and is a favourite variety in Mysore also, is a free fruiting variety and is so largely available that it may be called the poor man's fruit. The bunches under good cultivation are very large and compact and may carry up to 200 fruits. The fruits are bright, yellow in colour and the skin is thin. They are about 3 to 4 inches long, well filled and smooth and almost rounded, with a firm flesh which keeps fairly well. The fruit has a slight acid taste along with the sweetness. This is the most important commercial variety.

The 'putta bale' is very similar to the 'poovan' in shape, size and colour of fruit but has a slightly different flavour.

The 'Gujju bale' or Mauritius or dwarf plantain is a slow growing variety, with trunk seldom taller than four feet, and the leaves thick and dark green with short petioles. The bunches are very large and may carry up to 200 fruits, and reach down to the level of the ground. The bracts towards the tip of the bunch often persist even after the flowers have opened and dropped; and many diminutive fruits may be found crowded at this end. The bunches are compact and the fruits fairly long, being about 5 to 6 inches and slightly curved and about 1 to 1½ inches across. The ridges are not very pronounced. The skin is thick, peels off in two layers when ripe and the green colour

changes only slowly and slightly even when the fruit is quite ripe. The flesh is soft and becomes softer still and almost jam-like when very ripe. The fruit is very sweet, with a strong distinctive flavour.

The 'yele bale' or leaf plantain is specially prized for the sake of its leaves which are in demand for use as eating plates. The variety looks somewhat like the 'yelakki bale' but suckers profusely from which an abundant supply of leaves can be cut. On account of the numerous suckers, the variety attains great size growing almost like a thicket.

The 'red plantain', as its name implies, is peculiar in the colour of its fruits which are rosy red in colour. The variety is tall, large and very striking in appearance with large and long leaves, the rosy red colour colouring the petioles and leaf sheaths and even to some extent the leaves. It is a late variety and takes some 18 months to two years to yield. Both bunches and fruits are large. The fruits are about 6 to 9 inches long and quite 2½ to 3 inches across. They are almost uniform in size throughout their length with a blunt rounded end and the ridge almost smooth and rounded. The skin is rosy red in colour, quite thick and peeling off in two layers. The flesh is quite soft and the fruit does not keep, the flesh becoming very soft and like jam as the fruit becomes over-ripe. A light yellow colour blotched dark develops on the skin at this over ripe stage. The *flavour is strong and when over-ripe not pleasant.*

The peculiarities of certain South Indian varieties are summarised in the following table.—

Variety	Months taken for bunch to appear		Hands per bunch	Fruits per hand	Weight per fruit in *Oz.*
	January planting	June planting			
White chakkarakeli ...	10½	8	4 to 5	12	4·43
Mauritius ...	9½	6½	8 to 9	14	3·99
Bonthi ...	10	8	4 to 6	12	7·83
Kadali ...	13		7 to 8	16	2·4
Kommurati ...	10½	8	4 to 6	12	8·3
Namarai ...	9		5 to 7	16	1·1
Nadan ..	12		7 to 8	14	4·57
Sirumalai ...	9	7	7 to 8	14	3·36
Ayirakai poovan ...			40 to 45	12	2·66

(Madras Agricultural Journal, February 1937.)

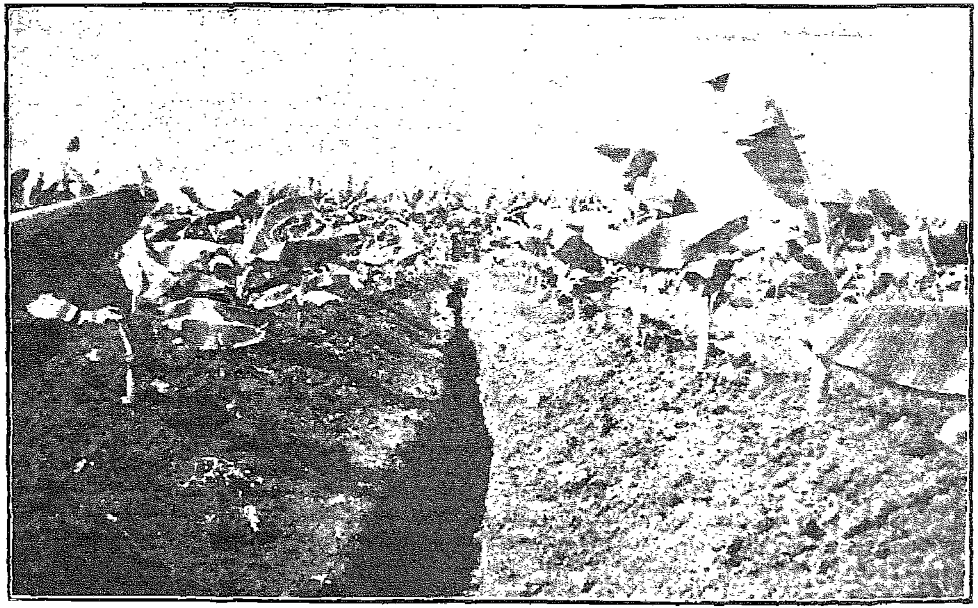
Pests and diseases.—Plantains are singularly free from insect pests — a rather remarkable and fortunate circumstance in the case of such a widely grown crop. The only pest of any importance is the stem weevil which bores into the underground rhizome and greatly weakens the affected plant, sometimes bringing about its death. The rhizomes of badly affected plants may be seen infested with the weevil grubs. No remedy has been

worked out; only preventive measures are possible, among which the most important is the discarding of infected rhizomes as planting material. The rhizomes of infected plants should also be removed, squashed up and buried deep.

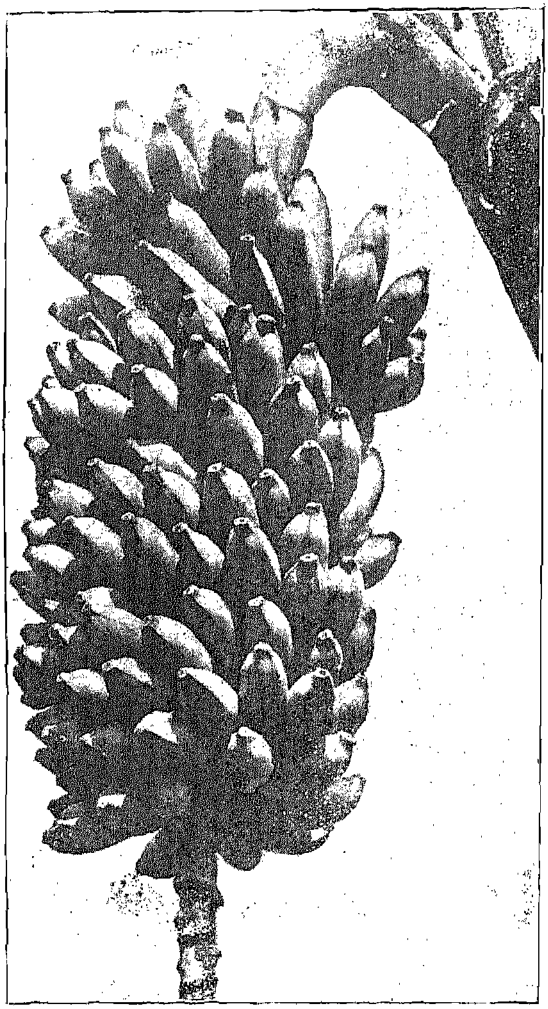
Minor leaf-eating insects and caterpillars and scale insects have been noted but the damage is insignificant. It is also remarkable that the fruit is free from the attacks of the fruit fly.

The plantain is subject to a serious fungus disease—*Sclerotium Rolfsii.* The fungus attacks the trunks or pseudo-stem of the plants, starting a kind of rot or softening of the tissue on account of which the stem breaks off at the weakest spot bringing down the crown (and the bunch, if one has formed at the time) with it. The disease attacks the stem sometimes long after the bunch has formed and is ripening. The disease appears to specially favour certain varieties such as the 'Rasa-bale' and the 'Maduranga bale' (in Mysore), being so bad on the former that it is impossible to grow it in certain sections. Remedial measures have not been worked out but trials with swabbing the affected parts at an early stage with Bordeaux mixture have shown that it can be kept down by this method. Lack of drainage and too heavy irrigation also appear to favour the disease.

Chemistry and uses —The plantain crop is put to a number of uses. The fruits are eaten before they are quite ripe as a cooked vegetable and prepared in a variety of dishes. Plaintains in fact form the commonest vegetable in the bazaar. Likewise the ripe and mellow fruit is the commonest fruit available and some of the varieties are very choice and delicious. The amount of actual food material provided by an acre of plantains may be said to exceed that from any staple article of food like wheat, rice or grain crop though of course the crop takes a whole year. The main and almost the sole food constituent in the fruit is carbohydrate, both starch and sugar, and though it is therefore by no means a complete food, as an energy producing product its value is very great. The average composition of the ripe fruit is as below:—moisture 74 to 80; fats (ether extract) 0·7; carbohydrates 25 to 18. Some varieties of the plantain lend themselves to be dried and ground into flour, which being practically all starch can be used much like tapioca, arrowroot or rice. Similarly some varieties can be dried after they are quite ripe and put up entire or cut in round discs and pressed together—in which form they are called 'banana figs'—and constitute an important dried fruit and are dealt with as a commercial product. Some plantains can be prepared into a fried article like potato chips, and though all of them can be so prepared, the 'nendiram' plantain of the west coast is deemed best for this purpose; the chips which are usually fried in cocoanut oil are a great delicacy and are eaten as such or salted or sugared. They



Field of young plantains, planted in heavy clay soil: note the deep trench which divides the high ridges. [Mys. Agri. Dept.



A good bunch of Poovan plantains. [Mys. Agri. Dept.

can be kept for several weeks and, well packed and protected, are sent out to distant markets from Malabar.

The green leaves find use as eating plates in Indian households and form an important article of sale, affording a small subsidiary income from the gardens. The dried leaves furnish immense quantities of packing material while the better class ones can be kept pressed and in shape and used as eating plates. They are stitched or skewered into cups and sold in very large quantities. The sheathing petioles of the leaves—which make up the so-called stem of the plant—are also put to a variety of uses. They form in their cool moist condition excellent receptacles for packing all kinds of fresh flowers, vegetable, betel leaves, seedlings for transport etc. When dry, they can be torn into long strips or strands and used as tying strings or bands, their pliancy, softness and strength making them better suited than twine or other cordage for many purposes. Torn into fine threads these are used for stringing together flowers into garlands. The tender and long fruit stalk inside the pseudo-stem is used after the plant is cut down, as a common vegetable both as a salad and in a cooked condition. The plantain plants themselves are greatly in demand for use in decorating the fronts of houses, welcome arches and wedding pandals, etc., for which purpose the plants are cut down to the base, bunch and all, and are tied alongside pillars where they make a great display with their gorgeous leaves and shiny ivory-like massive stems, and the inimitably elegant pendulous fruit bunch terminating in the large flower bud.

An article of great industrial importance is the plantain fibre, yielded by the leaf sheaths of one of the species—the Musa textilis—from which the famous Manila hemp is obtained. This fibre is made into cordage of extraordinary strength which is practically unequalled for all purposes other than under-water use. Many of the Indian plantain stems also yield fibre which is suitable for both cordage and textile purposes. The extraction of the fibre for these two industrial purposes has not so far been attempted on anything but an experimental scale.

II. POTATOES.

VERNACULAR NAMES FOR POTATOES:—*Kannada*—URULA-GADDE; *Tamil*—URULAKKIZHANGU; *Telugu*—URULA-GADDA; *Malayalam*—URULAKIZHANGU; *Hindustani*—ALU.

The potato was introduced into India only a little over a hundred years ago. It has become one of the most popular among the vegetables of the country and is grown over very large areas. It is moreover a commercial product of very great importance, which is due to the fact that with proper care it can be kept without much deterioration for some months, can be

handled or transported long distances without serious damage, and can therefore be marketed over the large consuming sections of the country situated far from the centres of production. South America is regarded as the home of the potato and it still continues to be the source of a number of wild and hardy varieties of the potato which are now explored by collectors in search of breeding stock for crossing with the cultivated varieties for the purpose of evolving varieties containing a combination of qualities like disease resistance, high yield and so forth. The discovery of America and the gradual over-running of the two continents by the European races led to the introduction of the potato into Europe, where its cultivation increased rapidly and has now assumed enormous proportions. It is a food crop of the first magnitude and has in recent years assumed great importance for industrial purposes also.

Distribution and Climate.—The potato is a crop suited only to colder latitudes and to the temperate zone and to the cold weather months of the sub-tropical climates. The crop stands a range of temperature from about 80 degrees as a maximum down to 55 or 50 and even lower provided frost does not set in. It can be grown from sea level up to an elevation of 7,000 feet. In the tropics its cultivation is possible only on the plateaus and hills, where alone the temperature is sufficiently low. It is a crop grown now in all parts of the world, where it is possible to obtain this range in temperature, but the important areas of production lie outside of the tropics. The whole of Europe, the two Americas, Australia, parts of South and East Africa, Japan and Burma are the important producing countries. Imports of potatoes into India come from Italy, Cyprus, Burma, Kenya, and Japan. In India the areas of cultivation are in Bihar and the U. P. principally, on the hills of the sub-montane tracts but considerable areas in the plains also during the cold weather, and around Karachi in Sind, parts of Bombay such as around Poona, Ahmedabad, Dharwar and Belgaum, on the plateau of Mysore, principally in the districts of Bangalore and Kolar, and on the Nilgiri Hills.

In India it is cultivated both as a purely rain-fed crop and as an irrigated crop. It is only on the hills and to some extent in favoured localities on the plains that the potato is grown as a purely rain-fed crop. The crop cannot stand heavy rainfall and the months of heavy rainfall, *viz.*, July and August, are therefore avoided and the crop is raised in the months of moderate rainfall preceding or succeeding these months. The rainfall during the crop season does not exceed about 30 inches. The main cultivation in the plains is under irrigation. In Mysore irrigation is essential in whatever season the crop may be grown.

Soils.—The soils suited for potatoes are well drained loams and sandy loams. The brown, light red and deep red loams are typical potato soils in the potato growing tracts of Mysore. They have great depth, are uniform in texture, and are singularly free

from grit, gravel and decomposing rock. They often get great accessions of sandy material from the sides and slopes of the rocky debris of the hills and the adjoining high level country. The black or dark brown clayey loams of the valley fields under tank irrigation are also put under potatoes, but large quantities of sand are carted to these fields every year to make them fit for potatoes and other garden crops. Good drainage, depth and a uniform smooth grit-free texture, open and loamy rather than clayey and freedom from kankar or even mild alkalinity are all looked for in good potato soils. Deep alluvial loams, river banks and old river beds also form ideal soils and are devoted to potatoes in several parts of the potato growing tracts.

Although the above are the best and most favoured type of soils for potatoes, the crop is sometimes grown in clayey soils of the black cotton soil type also. In southern Dharwar it is raised as a rain-fed crop in such soils and the produce is largely sent on to Mysore as seed potato for the following winter crop. Potatoes are also grown on soils more or less of the same type in European countries.

Rotation.—The potato as grown in this country especially in South India takes 3 to 5 months to mature according to the variety. The variety grown in Mysore takes only about 3 months or 3½ months to mature, and sometimes tubers are dug even before three months. The duration being so short, it is possible to grow two crops of potatoes in the year on the same field. Ordinarily where there is no difficulty for irrigation, three or even four different kinds of crops are grown in same year, and many crops enter into the rotation, some as catch crops and some as crops of longer or shorter duration than the potato. The potato is grown in two seasons called the summer and winter crop, which in Mysore correspond to the rainy season crop and the hot weather (besike) crop. As cultivated in Mysore the summer or rainy season crop is planted about the month of April-June and dug in the month of July-September, while the winter or the "besike" crop is planted about October-December and dug in the month of February-March. In other parts of India both in the hills and on the plains' the planting months in both seasons are often spread over a larger period than indicated above. Thus on the hills the planting of the summer crops is done from February to April and the winter crop in August to September. In the plains planting begins in February for the summer crop and in the months of September to December for the winter crop.

In the maidan tracts of Mysore the cultivation is under well irrigation mostly and the potato is grown as a garden crop in rotation with a number of other garden crops. Where water is not plentiful, the rotation is potato as the hot weather crop followed by ragi, as the main rainy season crop, or by chillies, or garlic or sweet potato, there being only two crops altogether in the year.

If water is plentiful then the 'besike' or hot weather crop of potatoes is followed by maize, or by vegetable crops like French beans or cucumber as catch crops; then follows the rainy season crop of potatoes, after which a crop of irrigated ragi, which matures in three months and for which seedlings are raised separately and kept ready. This is a very intensive rotation and the ragi is omitted sometimes and a fallow takes its place. In the following year the 'besike' or the hot weather crop of potato is repeated followed by the catch crops of maize or vegetables The next crop is chillies, onion or garlic which occupy the field till the end of the year, after which the following year's crop of 'besike' potato begins. In these tracts the cultivation of potatoes as a 'besike' crop is general and is the largest crop of the year. The rainy season (summer) crop is only on a small scale and is roughly estimated to be only about one-twentieth of the area under the former. This small crop is largely with a view to raising seed tubers for the succeeding 'besike' crop.

Seed Potatoes.—The planting material for the potato crop is the potato tuber itself, which is then commonly spoken of as seed potato. The potato tuber requires a resting period of 2½ to 3 months before it can be planted as seed potatoes. There are also varieties which require seven months of this dormancy. The period can be reduced by various devices but these are not applicable in practice, and storage has to be resorted to. The keeping of the potato for this long period is difficult owing to the deterioration which sets in, the attacks of the potato moth and generally the lack of suitable storage accommodation. In the case of the potatoes dug in the months of March—April, that is the 'besike' crop, the summer temperature of the following months makes it almost impossible to store them except on the hills, in a fit condition for seed. In the case of the potato grown in the rainy season, however, the crop after harvest can be stored for seed without difficulty as the weather is considerably milder in the following months. For this reason, a good deal of the crop grown in this season is stored for seed and every man tries to grow a small patch which will provide enough seed for his next 'besike' crop which is the more important and the main potato crop of the year. Few people, however, raise seed from their own crops in this way for more than two seasons. Seed is therefore, continuously replenished from outside and Mysore depends for its seed supply upon Dharwar, Poona and the Nilgiris. The extended period over which the crops of the two seasons are grown in the different areas makes it possible to meet the requirements of one tract from the crop grown in other tracts. Large quantities of seed potatoes from Italy form part the imports of potatoes into India and supply a continuous yearly succession of fresh seed stock. Italian seed potatoes arrive about November and are planted soon after the cold weather in the above tracts. Dharwar obtains the produce from

this planting and uses it for planting in the rainy season in the months of June-July. The Italian seed potatoes are generally planted in the districts around Poona, Ahmedabad and Belgaum and the produce therefrom is sent on to Dharwar where it becomes further acclimatised. A good deal of the seed potatoes brought into Mysore from Dharwar is Italian seed grown thus for two seasons in the country. A certain quantity of Italian seed is also got out direct from stocks in Bombay and planted out. This fresh Italian seed is not considered satisfactory; the plants are said to grow tall and run a good deal into leaf with a poor yield of tubers; the acclimatised Italian is therefore the seed usually got out and planted. The supply from Italy has been subject to serious interruptions during recent years and the situation may be said to have completely changed at the present time. Kenya is at present the only important outside source. Indian grown potatoes from the Bombay Presidency, the Nilgiris and Mysore itself supply all the requirements for seed in South India, while Upper Indian needs are supplied from hill potatoes in the north.

Cultivation.—Potatoes are grown as a garden crop in Mysore. The preparation of the land for the crop is careful and thorough. The area grown by individual cultivators is usually very small, amounting to often less than a quarter of an acre and seldom exceeding one acre. The cultivation is all by manual labour and quite intensive. The land is prepared by digging with hand tools to a depth of 18 inches or even two feet, the soil being raised in large clods. It is left in this condition to dry and weather for some time and then dug again to break the clods. Roots, weeds, stones and gravel are all removed from within the full depth and the ground reduced to a fine tilth. Sand and earth are spread and dug in and later cattle manure at the rate of 40 cart-loads per acre is applied and worked in. Manure from the city consisting of sweepings and night soil which are regularly carted and stored for the purpose is also applied instead of, or supplementary to, the cattle manure. It is also usual in the taluks around Bangalore to cart wool waste from the woollen mills in the city, and also leather waste consisting of fleshings and scrap and other refuse from the tanneries to supplement the cattle manure. After the manure is all well worked in, the field is laid out into beds for irrigation. These beds are generally 12 yards long and 4 yards broad. They are divided into sections across their width by means of low dividing bunds, each section being 2 yards in width and 4 yards in length. Along the length of the beds, furrows for planting the potato are made at distances of 10 inches or one foot from each other which give 10 to 12 rows of furrows in each bed. Along the middle of the sections and across the furrows small water channels are made, the water from which flows into either side each watering a section one yard by four yards on

either side of it. The larger beds run in a double series on either side of a larger water channel from which through laterals water flows into each of the small sections.

Before planting the potatoes, the beds are watered and the soil moistened thoroughly. If the field has become too wet it is left to dry during the day and planting is done in the evening or the following day. The seed sets are planted in the furrows at distances of about four to six inches from each other by pressing the cut set with the bud end up, about two inches into the soil. The seed rate per acre varies from 7 to 12 cwts. The beds are not watered for three days after planting. Light irrigation is then given once in three days. The tubers begin to sprout in a week and in ten to fifteen days are fully up and showing above the ground. A hand hoeing is now given and weeds are removed. The growth of the crop is now rapid and good irrigations are now given once in five days or a week.

In forty-five days the plants are well grown and the tubers begin to form. They are now earthed up by splitting the ridges and making them into furrows. Irrigation once a week or ten days is given liberally and the crop matures in another forty-five days without further attention. The leaves become yellow and the haulms and leaves also begin to dry. The tubers are now dug carefully, any bruising or cutting of the potato being avoided scrupulously. As the tubers part from the stolons with great ease the tubers need little beyond picking up. The tubers are generally clean and free from adhering earth except on the soils somewhat clayey which is exceptional, and require little or no special cleaning. They are heaped up in the garden covered with the haulms of the potatoes for a week, when the tubers dry a little and the skin adheres more firmly to the tubers. The produce is now roughly sorted to remove the very small tubers and then sent on to the market for sale. The larger growers however store the produce for some time to avoid the slump usual at harvest time and sell when prices improve. Storage is on good tiled or masonry floors in airy rooms where the tubers are spread in a thin layer and never heaped up.

Cultivation as rainfed crop.—To a small and somewhat insignificant extent in Hassan and Kadur, potatoes are raised as a purely rain-fed crop. The potatoes are planted in fields which are kept ready, well ploughed and prepared in the late rains after the previous year's dry crop of ragi has been harvested. This enables the planting to be made with the very first of the early rains in the month of April. The fields are further ploughed and worked with the bladed harrow and then furrows are ploughed both lengthwise and crosswise at a distance of 18 inches from each other, laying the field into 18 inch squares. At the intersection of the furrows a whole seed potato is planted. After the crop begins to show above ground the interspaces are worked with the bladed harrows to remove weeds and then the

interspaces are ploughed. Before ploughing, a little cattle manure is put around the potato plants. Some three furrows are ploughed both along and across these interspaces and the potato rows are thereby well earthed up. With regular rainfall the crop matures normally and yields quite a good crop of large sized tubers, sometimes equal to the yield under irrigated cultivation. For large scale cultivation under conditions of suitable rainfall, the method is quite suitable and is, as a matter of fact, adopted. Thus in the Dharwar district furrows for planting are made two feet apart and the tubers planted 18 inches apart in the rows. The potatoes are planted either whole or cut into pieces or 'sets.'

Planting of cut sets and of whole potatoes.—Where the cultivation is at all large on anything like a field scale and not in the manner of the garden cultivation as practised in Mysore, the seed tubers are planted whole. Usually it is only the small tubers that are reserved for seed, the medium and the larger ones being sold for table purposes, the consideration being one of economising cost. The smaller tubers however yield tubers of only small and moderate sizes with only a small proportion of large sized tubers while if medium and large size tubers are planted there is a high proportion of large tubers. In some places tubers of different sizes are planted in separate fields, or some growers plant large tubers, others only small or medium ones, depending upon the market to which the supplies are made, and the general trend of prices for the different grades. This difference between planting large and small tubers is reflected more in the size of the potatoes obtained and in the relative proportion of the large and small rather than in the actual tonnage of the crop yielded. In planting cut sets, seed is still further economised and the cost is greatly reduced. In addition to this economy, the planting of cut sets has the advantage that the interior of the tuber can be inspected, and diseased tubers detected and discarded. This is especially the case in the 'ring' disease, one of the worst of potato diseases. Seed tubers affected with the disease though outwardly sound possess inside a characteristic brown or dark 'ring' of affected tissue along the margin which is seen when the tuber is cut across. This is the only way in which it can be detected. If such tubers are planted not only do they infect the plants round about but also infect the soil and make it unfit for a succeeding crop of potatoes or other solanaceous plants. The discarding of such tubers is therefore of the greatest importance and this is made possible only by the method of planting cut sets. Sets may be cut small or large; in the latter case the tuber is cut into two along the length, so that the eye buds are about equal in number in both the sets. The cut is made from the bud end to the stem end of the tuber. When cut into smaller sets, they are so cut that each set has at least one good 'eye'. It is necessary

to have a glass of dilute permanganate of potash solution handy when the seed sets are being cut, so that in case diseased tubers should be cut across, the blade of the knife may be dipped into the solution before cutting another tuber as a safeguard against infecting sound seeds.

Yield.—The quantity of seed required to plant an acre is from 7 to 12 cwts., in the way in which it is cultivated in Mysore. Yields are generally tenfold, and a good crop yields up to 500 maunds or about six tons an acre. Average yields are reckoned as only about three to three and a half tons an acre.

Botany and Varieties.—The potato plant, distinguished botanically by the name 'Solanum tuberosum,' belongs to the natural order 'Solanaceae' which comprises some important field and garden crops as the brinjals, tobacco, chillies and the tomato. The potato is the swollen end of underground stems, called stolons which branch from the main stem underground and grow somewhat horizontally and develop into tubers at the end. As a swollen stem the tuber bears several eye-buds which in time can grow into new stems and leaves and if planted in the ground give rise to new plants. If the 'eyes' on a potato are removed or damaged, the potato cannot give rise to a new plant and therefore potatoes with damaged or moth-eaten eyes are unfit for being planted as seed potatoes. The potato plant has a thin herbaceous stem which grows to a height of about a foot or a foot and a half, but some varieties grow to a height of two feet or thirty inches and have a tendency to bend down and lie almost flat on the ground for want of support somewhat like an unstaked tomato plant. The roots spring from the base of the young stem and branch into two or more main roots and rootlets which traverse a depth of about a foot. Springing from about the same point on the stem are stolons or underground branches which grow almost horizontally and close to the plant itself generally at a depth of four to six inches. These stolons send down roots further down and at the end swell into tubers, large or small. These tubers begin to form about six weeks after planting and then grow in size. According to the variety, the tubers are found very close to the plant almost hugging the base or up to a distance of about six to nine inches and likewise lying deep or shallow according to variety. The ripe tuber passes through a resting period of about three to five months and then starts growing from the eye-buds, whether left in the ground or after harvesting and keeping that length of time. The leaves are compound and pinnate, the leaflets being somewhat ovate with a narrow pointed tip depressed along the midrib and often showing a crinkled appearance. In addition to the larger leaflets, there are smaller ones of the same shape which almost appear like leafy bracts at the base of the leaf stem and between the larger leaflets. The potato plant will sometimes bear flowers; in some varieties more plants bearing flowers can be

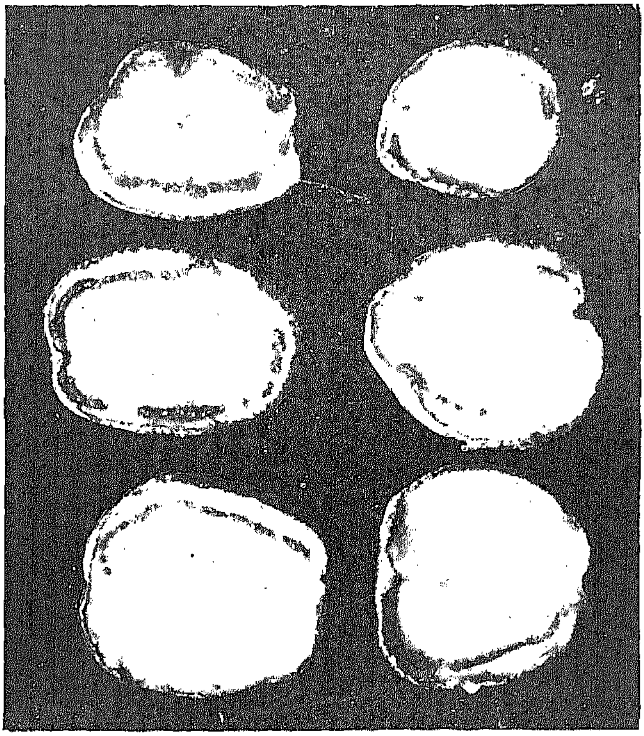
met with and in others none at all. The propagation by means of the tuber for generations has evidently deprived the plant of the flower bearing habit almost entirely. Even among the plants that do flower, the flowers merely shed away without setting fruit ; but occasionally plants are met with in which the flowers set fruit which ripen and produce seed. The potato flower is very much like the flower of the brinjal, some white and some light blue in colour, and consists of a calyx with five segments, a corolla with five petals, and five stamens in which the anther lobes surround and cover the pistil like a hood. The fruit is a rounded berry about the size of a marble, with the seeds in two cells. Though all seeds are not viable, many can sprout and give rise to new plants. As the potato plant is cross-fertilised in nature, the plants raised from these true seeds often give rise to varieties quite different from the parent plant. This is taken advantage of in securing new and better varieties of potato and these new varieties can in turn be easily propagated vegetatively by planting their tubers.

There are many varieties in the cultivated potato which however all resemble each other in most of the general characteristics. Among wild types recently explored in the South American Continent which is regarded as the home of the potato, some remarkably diverse forms have been discovered which differ from each other and the cultivated potatoes in many important respects such as habit of growth, height, fruiting habit, size, shape and colour of the tuber, freedom from disease and so on. As far as the cultivated varieties are concerned, they differ principally in the tuber characters, such as colour, shape, size and quality of the flesh of the tuber. Broadly they may be said to fall into two classes, the waxy potatoes and the mealy potatoes. The flesh of the former as the name denotes is firm and holds together when cooked, whereas the latter when cooked breaks down into a soft somewhat powdery meal. The waxy potatoes are also somewhat yellow in the colour of the flesh while the mealy kinds have a white flesh. Varieties differ again in the colour of the outer skin or rather the skin just under the epidermis. While in the large majority the colour is the familiar corky brown made somewhat deep or light according to the colour of the soil in which it is grown, there is a class in which the colour is deep purple. Varieties differ in the shape of the tubers; thus, some are round, and others are flattish and oval—the so called 'kidney' potatoes—and others again are somewhat pear-shaped ; some are smooth with very few eyes and others have many eyes. Again in some the eyes are deep and sunken giving the potato a highly pitted appearance, while in the others the eyes are almost on the surface. The presence of many eyes and of the sunken type is a great disadvantage in peeling as against the ease of peeling possible in the smooth potatoes. Varieties differ to some extent in the period they take to mature,

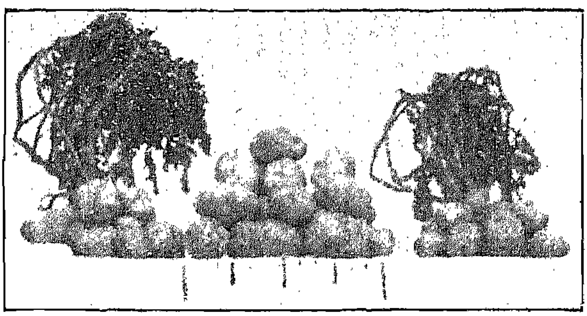
some are late and some a little early. Differences also exist in their productivity and hardiness or ability to withstand a break in the irrigation. Varieties differ also in the size of the tubers they yield, and in some the predominant type is large while in others the small sizes predominate. The varieties cultivated in the different parts of India are said to comprise some thirty in number, but those of commercial importance are only about eight. The varieties in Mysore are only two in the main, *viz.*, the round, many-eyed waxy potato called Dharwar—which is the acclimatised Italian white round, and the large flattish oval smooth mealy potato called Ricketts. The latter is somewhat early, taking about two to three weeks less than the Dharwar but it is somewhat delicate, requires regular watering without any long break. The varieties grown on the Nilgiris—the important potato tract in South India—are largely two, *viz.*, the Great Scot, a large round potato with several deep eyes, and waxy yellow flesh and the Royal Kidney a large flattish oval type white fleshed and mealy. Several new types have been introduced and these are now grown on comparatively small areas. These are British Queen, Up-to-date, Magnum Bonum, Ben Cruachan, Late Carman and Arran Comrade. The Bombay types, largely the 'Italian White Round' called the Dharwar in the Mysore State, and the Upper Indian varieties comprise three types, white round, coloured round and coloured oval. In the white round type come the 'Phulwa' class which is the only class which flowers in the plains. It also comprises another class 'Gola' which is an early variety taking only 65 to 75 days to mature a crop. In addition a large number of European introduced varieties are also grown to some extent.

Pests and Diseases.

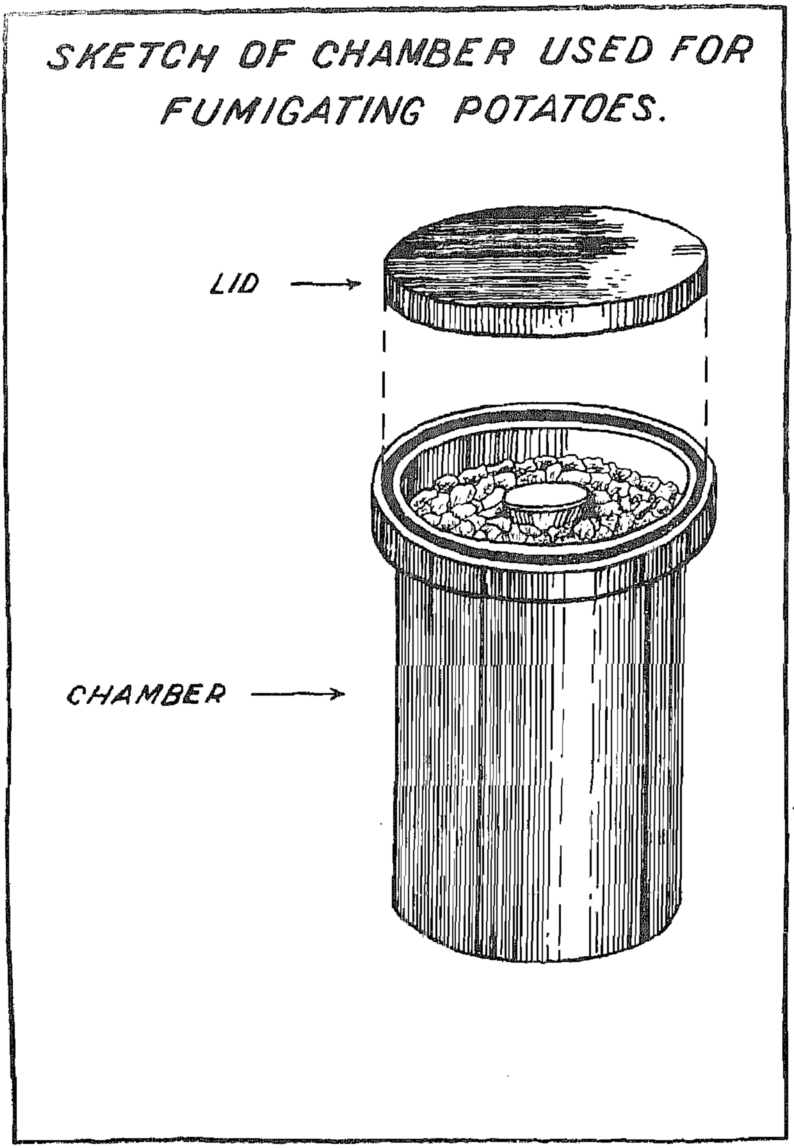
Insect Pests.—The potato is subject to several insect pests. These are (1) Epilachna beetles, on the leaves, (2) cut worms on the tubers and the stem, (3) the potato moth on potatoes in storage and in the field. The Epilachna beetles are a leaf-eating pest. The grubs of the beetle eat the green material of the leaf and the stems and the leaf petiole, turning the leaf into a patch work pattern of the cellulose skeleton of the leaf and weakening the plants greatly. In bad cases serious damage is done and the growth of the plant prevented or much retarded. The broods appear in quick succession and adult beetles, pupae, and the leaf eating grubs can all be seen on the plants at the same time. The control measure consists in keeping a sharp look out for these grubs in the plants and to handpick and destroy them. This will effectively prevent the spread of the pest. If no notice has been taken in the early stages and the pest has consequently increased greatly, then the plants will have to be sprayed with a stomach poison such as lead arsenate.



Cut surfaces of potatoes attacked with 'Ring Disease', showing the *characteristic black ring of affected tissue, along the margin.*
[Mys. Agri. Dept.



'Up-to-date' potatoes, showing the size and shape of the potatoes and the produce of individual plants.
[Mys. Agri. Dept.



Chamber used for fumigating potatoes against the 'potato moth'.
[From the Report on the Marketing of Potatoes.

Cut worms are an underground pest and damage the plant by cutting the stem away at the bottom as the result of which the plants wilt and die. The wilting of the plant is often likely to be mistaken for a similar symptom due to the ring disease, but if the soil around the stem is slightly removed, the attack of the cut worm can be made out. The soil for a short distance around the plant will have to be searched for the cut worms which generally are not far from the plant attacked and should be found and destroyed. If the stem is not completely cut through, the plant can be saved by earthing it up and preventing it from breaking off. The field should be gone over then to see if any plants are wilting and such wilting plants, if any, should be examined and treated as above. As these grubs are generally present in the cattle manure used, the manure should be examined for these when it is being applied and grubs when found should be destroyed.

The potato moth (*Phthorimoea operculella, Z*) is a serious pest of stored potatoes. The eggs are laid in the eye buds of the potatoes; the grubs on hatching out destroy the eye buds and then tunnel under the skin and into the flesh of the potato. Owing to the damage by the borer and the rot which sets in as a result, these potatoes become unsaleable as edible potatoes. As seed potatoes they are still more unsuitable, not only because the eye buds have been eaten and the potato cannot sprout but also because the crop in the field can also become attacked and the pest brought into the store again in the infected potato. By far the greatest damage takes place however only in the stored tubers. Control measures are (1) to inspect the potatoes to be stored and separate all tubers showing signs of attack by the borer, which may be sold and to store only healthy sound potatoes, (2) to keep the store or godown clean and well swept especially in the corners and cracks so as to remove pupae of the moths from the store, (3) to keep the sound potatoes under a layer of sand about 2″ to 4″ deep. Tubers will have to be taken out and inspected for rots due to other causes and every time after such inspection is made and the damaged potatoes removed, the produce will have to be put under sand again. The tubers are spread in a layer of about 9″ to 12″ preferably over a bed of dry sand, and then covered with a 2″ to 4″ layer of sand. For the preservation of potatoes intended for seed or when the quantity to be stored is not large, this method will be found quite suitable and effective. In Bombay fumigation with petrol is the method adopted to rid potatoes of the moth before it is stored. The method is described under 'Storage of Potatoes.'

DISEASES.

1. *Bacterial Wilt.*—The potato is subject to a bacterial disease—called Ring Disease, or bacterial wilt—which is perhaps

the most serious disease of the potato in South India. The presence of the disease can be made out in the affected tuber, by a dark or brownish ring, sometimes complete and extending to the full circle of the vascular tissues or showing only in a part of this line, which is seen when the tuber is cut across. The ring of the discoloured tissue commences from the base of the stem end or the union of the tuber with the stolon and traverses the circle in whole or in part. The affected vascular bundles are filled with the bacteria causing the disease, *viz.*, *Bacillus solanacearum*. Plants affected in the field begin to droop, wilt and gradually die away. In the early stages the wilting can easily be mistaken for the attack of the cut worms. The wilting is due to the blocking or choking of the vascular bundles by the millions of bacteria growing and multiplying in them and thereby preventing the rise of water and sap into the stems and leaves above. In bad cases a very large number of plants become affected and serious loss is caused.

The wilting is generally seen to commence after the plants are somewhat well grown usually about six weeks after planting. Moreover before the plant completely dies down, several tubers have already formed. The result is that infected tubers can be found in nearly all stages from very young tubers to those which are quite mature. This accounts for the presence in both commercial edible potatoes and in seed potatoes of a more or less large number of tubers which are infected and show the disease clearly when cut across. The infected tubers rot more readily in storage, and cause loss in that way also. It is indeed recommended that such potatoes should be dug early and sold without being stored for any length of time.

The disease gains entry into the plant in one of the following ways, *viz.*, (1) infected seed tubers, (2) infected soil, and (3) the irrigation water flowing past infected plants and carrying the infection to other plants in the row. Infection through the agency of insect vectors is not excluded but has not been found an important source in India.

Control measures are only of a preventive character. The greatest care is required in selecting disease-free seed tubers. Generally the standing crop is inspected by the prospective purchaser of seed to see if it is free from diseased plants. Seed is also purchased from tracts which are considered disease free. When cutting sets for planting, those sets which show signs of the disease have to be rigorously excluded, and after an infected tuber has been cut, the blade should be cleaned by dipping in permanganate of potash or alcohol before cutting another set so that in case the latter should be a sound tuber it should not become infected by the blade. No potato crop should be grown on soil on which the previous crop was infected, and a field once infected should not be put under potatoes, chillies, tobacco or brinjals for some years. The exact period of this interval is not

known, but three seasons of a non-solanaceous crop for which the cultivation includes a good hot weather digging and weathering of the soil have been found to give sufficient protection. As a matter of fact careful cultivators follow the potato crop with non-solanaceous crops like irrigated ragi, maize, peas, beans and so on, for a couple of seasons before putting the field under potato again. This will generally mean an interval of eighteen months including a good hot weather fallow of deep digging.

A method of seed treatment by which the seed potato is sterilised without impairing its germinating capacity has been stated to be effective in controlling the disease. The method consists in subjecting seed potatoes to dry heat at a temperature of 53°C. for a period of four hours. At this temperature the *Bacillus solanacearum* is completely killed out even after an exposure of ten minutes. After the four hours' exposure to this temperature, the seed potato is free of the living bacilli and when planted gives rise to plants free from disease. The treatment does not injure the germinating capacity of the tuber. The method does not appear to have been tried on anything but a laboratory scale.

2. *Alternaria.*—Another disease causing much damage and which is of more general occurrence is the '*Alternaria solani*, or 'early blight.' The disease appears in the form of brown spots on the leaves generally of the well-grown plants, which increase in size causing the curling and drying up of parts of the leaves. Plants are not killed out but further growth is retarded and the plants are greatly weakened and depleted largely of the reserves in the leaves for the development of the tuber. The result is poor tuber formation, only small tubers and few in number being formed and the crop becoming greatly reduced in both quantity and quality. The disease appears when the season is rather dry and irrigation water is not plentiful and soil and manuring not of the best and also on the varieties which are newly introduced. Fortunately it can be controlled very effectively by spraying with Bordeaux mixture. The spraying should be done as soon as the disease appears, and for this purpose the crop should be watched for the signs of the disease. It may be necessary to repeat the spraying a second time. In the early stages the crop should be stimulated if possible with a little more manure and heavier irrigation.

3. *Irish Blight.*—The most dreaded disease of the potato which often appears as an epidemic and which at one time devastated the potato crop of the whole of Europe, notably in Ireland, leading to conditions akin to famine is the 'Potato Blight'—*Phytophthora infestans*, also called 'Irish Blight'. It is known to have occurred in Bengal in an epidemic form in the year 1913. Owing mainly to the high temperatures in the plains, the disease does not occur under Indian conditions though in an endemic form it exists in the potato tracts

of the hills. The disease appears when the plants are two to four months old and causes the death of the plants within a startlingly quick period. The affected plants show brown patches on the leaves, which increase and extend to the stalk rapidly, causing the plant to wilt and fall over and rot in a day or two, giving rise to a black evil-smelling rotten mess. The underground parts and the tubers are also affected; a kind of wet rot sets in on account of which many tubers rot away completely before harvest. In dry soils a dry rot sets in, in which the surface of tubers show irregular depressions with a corresponding drying of the tubers inside; such tubers can however be harvested and stored although when used as seed they may or may not give rise to the disease according to circumstances. Where the mean temperature exceeds 77°F., the disease is said to be unknown, and the manner in which the disease is carried over from one year into another is rather obscure. Heavy nitrogenous manuring giving rise to over luxuriant plants is regarded as a pre-disposing cause in addition to weather conditions. The control measure consists in spraying the plants with Bordeaux mixture which should be done much in advance of the outbreak of the disease in areas where the disease is known to occur. In India the disease does not occur normally to any extent, though in an endemic form it exists on the hills, the seed supply from which may, if weather conditions should unfortunately be favourable in a year, start the disease.

4. *Scab.*—Potatoes are also subject to 'Scab', a condition in which the outer skin of the potato tuber becomes dry, crusted and corky in patches. This condition is brought about both by several parasites (Oospora, Spongospora, etc.,) and also probably by non-parasitic agencies. The disease is not met with in South Indian potatoes. The disease when present is controlled by treating the seed potato (whole) in a solution of mercuric chloride (corrosive sublimate) made up of 4 ozs. of the material acidulated with two pints of commercial hydrochloric acid and diluted with 25 gallons of water. The seed tubers are dipped in the solution for 10 minutes and then dried immediately and stored. The method is of course useful only to destroy the fungus on the tubers and does not prevent entry from the soil or other sources.

5. *Warty potatoes.*—Potatoes are subject to a kind of malformation in which warty outgrowths develop on the potatoes looking sometimes like small eruptions and sometimes like larger warts. The growths are due to the attack of eelworms in the soil, and occasionally one or two of these can be seen embedded in the tissue of the affected potato. These warts give a most ungainly appearance to the potato which cannot for that reason be easily sold. The disease can infect the soil by the planting of such potatoes as seed, and the discarding of such potatoes from the seed lot is therefore a necessary precaution

against the disease. Deep cultivation and the weathering of the soil in the hot summer, combined with the planting of other crops like grains and pulses instead of potatoes in such soils will help to rid the soils of the eelworms.

Storage of Potatoes.—Among the methods of storage commonly adopted comes firstly the storage under sand to which reference has already been made. The potato layers are a foot high and are covered full by a 2″ layer of sand. After a week they are taken out and if heat has developed in the heap the stock is left uncovered for a couple of days, the damaged tubers are removed and the sound potatoes put under the sand again. This process of opening the heap and removing the damaged tubers has to be repeated several times. A second practice is that of keeping the potatoes in baskets arranged in a platform, the potatoes being examined now and then to remove the damaged ones. A third practice is adopted in parts of Bombay: potatoes are stored in pits dug in the fields. These pits are 18″ deep and 2½′ to 3′ wide with length to suit the quantity to be stored. The pit is filled with water and after the water has soaked in, the sides and bottom of the pit are lined with 'neem' leaves (Melia azhadirachta) the tubers put in and piled up about 3½ feet high and covered with the same leaves and then with earth. A trench is dug arround the heap and water allowed to stand to keep the heap cool. A variation of this method is adopted in the C. P. In this method ventilation shafts are provided for these heaps, by means of long bamboo hollows (with the septa at the nodes knocked out) which are stuck like chimneys at regular intervals, the lower ends planted inside the heap and well secured and the upper end open and communicating with the atmosphere outside. A system of fumigating the potatoes prevails in Bombay and it is carried out in this way, *viz.*, good cement lined pits cylindrical in shape, seven feet in diameter and six feet deep, with the upper lip made in the shape of a circular gutter are constructed and the tubers tied up in bags are put into these pits. The pits are provided with lids of wood or iron, the rim of which fits loosely into the circular gutter; water is filled into the circular gutter and when the lid is put on, it becomes air tight. Cotton wool soaked in petrol is placed in small trays in the pit in several places as the store is being filled and then the lid is put on. The potatoes are left thus for 24 hours, and this period is found sufficient to kill all the moths. The fumigation does not kill the eggs, and so after ten days the potatoes are fumigated a second time, when the larvæ hatch out and are killed by the fumes.

Cold Storage.—A great deal of loss takes place in these methods, mostly by driage and rotting. The loss may range from 20 per cent in the best conditions and up to 70 per cent in bad conditions. Storage without much loss can be effected only when it is under very low temperatures. Experiments over a series of

years in the cold storage of potatoes have shown the following :—(1) at 35° F sound potatoes can be stored almost indefinitely without sprouting; at higher temperatures the tubers sprout in storage at varying intervals and at 40° F. they can be kept without sprouting for about nine months, if the tubers are stored immediately after harvesting; at lower temperatures than 35° F. the tubers developed "black-heart" disease, the inside of the tuber becoming black and hollow. (2) at 35° F. and 40° F. storage does not impair the germinating capacity of the tubers; after storage for the desired period potatoes taken out and kept at 68° F. sprout vigorously. The period required for this germination decreases with the increase in the period of storage at 35° F. and 40° F. (3) The loss in weight of stored potatoes kept in bags or crates was about 5 per cent after storage for five months at 40° F. In practice therefore storage at temperatures between 35° F. and 40° F. is found a very effective method of preserving potatoes whether for seed or table purposes. Cold storage facilities intended exclusively for potatoes now exist in several centres in India, such as Meerut, Sialkot, Patna, Jammu and Karachi.

Chemistry and uses.—The potato as a food crop is remarkable in that the amount of food material it yields per acre is higher than that yielded by any other food crop including the cereal grains—wheat or rice. A six ton crop of potatoes which may be taken as a good crop will contain about $1\frac{1}{2}$ tons of starch, a quantity which cannot be approached by the best crops of wheat or rice. Potatoes are almost exclusively a starchy food. The potato is both a human food and an important food for cattle and pigs. In India the production is not so great as to warrant its utilisation as anything but a human food.

The chemical composition of the potato is as follows :—

Moisture 75 per cent, albuminoids 2·1 per cent, fats 0·3 per cent, carbohydrates 20·6 per cent, crude fibre 1·1 per cent and ash 0·9 per cent.

In addition to its being an important article of food, potatoes are used for several industrial purposes, notably for the manufacture of farnia or starch and for the production of alcohol. The farina or potato starch is largely in demand for use in laundries, for sizing yarn in the textile mills, and for the preparation of puddings, pastry etc. In India rice starch is used for these purposes but farina is also imported by textile mills to the extent of some 4,000 tons valued at nearly Rs. $6\frac{3}{4}$ lakhs per year.

The utilisation of potatoes for the production of alcohol is an important industry especially in Germany, where the alcohol is used mainly for industrial purposes. The residue left after the fermentation of the potato starch is a highly nutritious cattle food and is utilised largely for that purpose. A ton of potato is reckoned to yield 20 gallons of 95 per cent alcohol.

Other uses for industrial purposes are the production of dextrin and glucose.

As a food product itself, potatoes are also largely converted into dried potatoes and products known as 'dried', 'sliced', 'shredded' or 'rice' potatoes are prepared on a large factory scale. For this purpose the potatoes are peeled, sliced, shredded, or cut, slightly steamed or immersed in boiling water for some minutes and dried either in the sun or in special drying chambers. For other products the peeled potatoes are steamed and crushed, and the pulp dried and flaked by passing through hot rollers. These dried products keep a long time and are suitable for transport to long distances.

Production and Trade.—The area under potatoes in India (1939) was estimated at 448,700 acres, of which about 90 per cent are grown in the plains and the remainder on the hills. The main areas of production are in Upper India which accounts for 80 per cent of the area. The area in Bombay is estimated at 24,500 acres. In South India the Nilgiris has an area of 14,200 acres under potatoes and Mysore has 5,700 acres. The annual production in India is estimated at 1,700,000 tons in addition to which the country imports about 50,000 tons every year. There is also a small export of potatoes from India to the extent of about 4,000 tons per year. The export is mainly from Mysore which accounts for over 45 per cent of the total exports, while Madras (Nilgiris) accounts for about 31 per cent. The bulk of the exports amounting to over 75 per cent is shipped to Ceylon.

III. TAPIOCA (Manihot utilissima).

VERNACULAR NAMES FOR TAPIOCA :—*Kannada*—MARAGENASU ; *Tamil*—MARAVALLI KIZHANGU, EZHELAI KIZHANGU ; *Telugu*—KARRA ; *Malayalam*—MARACHINI KIZHANGU.

Among the miscellaneous food crops of South India the tapioca or cassava plant occupies an important place. Over many parts of the country the crop is grown with great ease on nearly every type of soil, on good cultivated fields, on rough undulating land and hill slopes and with comparatively little attention and expenditure yields a surprisingly large amount of valuable food material in the shape of its abundant edible roots. These can be consumed directly as food or first converted into tapioca flour and then used for food purposes. When grown solely for the sake of the tapioca flour, the crop assumes industrial importance, is grown on a large scale and the roots produced are handled on a factory scale by special machinery. In India it is at present grown only on a small scale by individual cultivators for their own household needs or for petty trade. The conversion of the produce for food does not involve any troublesome

processes at all, as the roots require nothing more than steaming or boiling. Some varieties indeed can be eaten raw. The crop is comparable with the sweet potato in this respect, but the produce is more abundant, the cultivation less laborious and the soil and other requirements less exacting. As a poor man's food there are few crops to equal it. Its introduction into South India, especially in Travancore, was with the object of relieving distress and as a substitute for rice; its immediate popularity which it still continues to maintain shows how well it is adapted for this purpose. Its cultivation deserves to be extended largely in the country.

Distribution, Climate.—The tapioca plant is said to be a native of Brazil, South America, where it has been grown from ancient times and exists in a large number of varieties or races, which possess marked differences. It is predominantly a crop confined to the tropics and a zone on both sides of the equator up to the 25th parallel of latitude may be taken to be the limits for its satisfactory cultivation. The crop does not stand much cold and, while frost is fatal, even under the moderate cold weather of northern India the crop does not do well. With the advent of the cold weather months of November and December, if the plants are left standing, they tend to shed the leaves and the roots too are said to soften and lose quality. The crop can flourish from sea level up to elevations of 3,000 or 3,500 feet, above which the low temperatures of the cold months make the tracts unsuitable. The crop can however stand very heavy rainfall even up to over 100 inches. Under the regular and abundant rains of the tropics the crop luxuriates and in these areas it can be grown purely as a rainfed crop. Many hill slopes and undulating country which cannot be put under ordinary field crops can under these conditions be cultivated with the tapioca like a plantation crop. In the plains and the tracts of moderate rainfall the crop requires irrigation and indeed has to be grown like a garden crop.

The crop is said to have been introduced into India variously, *viz.*, (1) by the Portuguese, (2) by the Dutch through the East Indies into Ceylon and India and (3) through Spanish influence into the Phillipines from where it passed into Indo-China, Burma, Assam and Eastern Bengal. In South India tradition has it that its introduction into Travancore was due to the efforts of one of its rulers who wisely foresaw its great potential usefulness as a food crop to the people of that country. It is as a matter of fact in Travancore and the west coast districts that it is an important crop at the present time forming the staple food crop of many poor people.

Soils.—Well drained garden loams are the soils best suited for the crop. The lighter somewhat sandy loams are preferable to those with a higher clay content. In the east coast districts it is mostly on such sandy soils that it is grown. On the west

coast however it is the lateritic loams, which are decidedly clayey loams and which form the predominant type of soils there, are the soils which are and indeed have to be put under the crop. These soils are however improved in texture and enriched by additions of leaf mould, ashes and household refuse. Drainage is of great importance and the slopes and hill sides are naturally well situated. The crop also likes open sunny situations and does not do well under shade. It is furthermore considered to be an exhausting crop and the crop which follows it in the rotation has to be heavily manured. The crop takes from eight months to twelve months and even more to mature and harvest, according to the variety. It therefore becomes the only crop of the year on the land. It is usually grown pure, but occasionally it may occupy only a few rows either along the margins or in the midst of other crops.

Cultivation.—The land is dug or ploughed as for garden cultivation and well prepared by the breaking of clods, removal of stubble and weeds and roots, etc. The soil is also lightly manured with five or six cartloads of cattle manure per acre. The manure may also be added at a later stage if the planting is to be in pits and not in furrows. Deep furrows are made at distances of three feet from each other and the field is laid into beds suitable for irrigation. On upland soils and generally under rainfed cultivation pits are dug about nine inches deep and at distances of three feet in the rows, which are three to four feet apart. The preparation of the field is carried out and finished in time for planting the crop in the month of May (in garden cultivation), or at the beginning of the monsoon rains at the end of June. The month of September is also one of the planting seasons, especially where the situation is moist and earlier plantings may be too wet for the crop.

The planting material consists of short lengths of the stem of the plant which are obtained when harvesting a previous crop. These cuttings are to be taken from portions comparatively young though ripe, and not from the woody bottom or the too tender tops. The cuttings vary in length in different places; four inch cuttings are used in some places, while in others even two or three feet cuttings are used. Cuttings about eight to nine inches in length and having four to six good nodes each will be found quite suitable. The cuttings are prepared by making the lower end somewhat sharp pointed by means of a slanting cut for facility in pushing it into the soil. Cuttings are planted by sticking them upright or slantingly into the moist soil so that at least three nodes show above ground. Cuttings may also be planted by laying them flat and pushing them a couple of inches deep into the soft mud.

The cuttings sprout from the nodes within a week and after the leaves are well opened the first weeding is given. The stem begins to make rapid growth and when the plants are two

months old another weeding is given and if possible a light manuring also. Not more than three branches are allowed per plant. Normally a height of eight or ten feet or even more is attained according to variety before the plants mature. For good root development it is some times advised that the plants should be topped and not allowed to grow more than six feet in height. From about eight months onwards the roots are mature enough to be dug but a trial digging should be made of a few plants here and there to make sure and then the general harvest may begin. Harvesting consists in cutting the plants down and then digging out the roots. The roots may be about three inches in diameter, 12 to 18 inches in length, and may weigh from 2 to 5 lb. each. If left for many months, and in certain varieties, giant roots weighing as much as 24 lb. each can be seen in rare instances. A plant generally carries four to five moderately good sized roots. When cultivated merely for the household, it is usual to dig the roots as they are required in small lots every now and then and spread the harvest over some months until all the plants have been cut.

Yield.—The yield of raw roots in varieties maturing in eight to twelve months may vary from 10,000 to 16,000 lb. per acre. The yield in Ceylon is reported as even higher, *viz.*, 10 tons an acre. Even higher yields are obtained, as for instance, 15 tons an acre which was obtainad in certain trials in the West Indies. The longer duration varieties give much higher yields than the short duration varieties. The roots lose quite 75 per cent of their weight on drying, and the outturn of tapioca floor is 50 per cent of this dry weight (Ceylon figures).

The leaves form excellent fodder; for this reason the crop has to be carefully guarded against stray cattle. The latter may indeed be said to be the only serious 'pest' of the crop.

Botany and varieties.—The tapioca plant—Manihot utilissima—belongs to the natural order, Euphorbiaceae, and the genus Manihot to which also belongs the 'Ceara rubber' tree. The plants have tall thin straight stems which are marked along their length by numerous leaf scars. The stems vary in colour, being green, greenish white, light red or deep red according to variety; these colours correspond with that of the petioles and veins of the leaves, in each case. The plants grow to a height which varies from six feet to eighteen feet according to variety. The leaves are five lobed or seven lobed, with a long petiole. Petioles and veins are either green, ashy green, or red, and in an ornamental variety, the leaves are mottled and striped green and white. The plants do not flower freely and often do not flower at all in cultivation. The flowers are inconspicuous, have a three celled superior ovary, which ripens into a capsule with three seeds. The plants possess large edible roots richly stored with starch, for the sake of which alone they are cultivated. The roots ripen and mature in from 6 months to 18 months

according to variety. There is said to be a very large number of varieties both cultivated and wild in the native home of the plant, *viz.*, Brazil, which differ in many characters such as the colour of the leaves and stems, shape, colour, roughness, length of leaves, height of growth, period of maturity, yield and quality of the roots. A most striking difference which is of economic importance is the content of a bitter principle, a cyanogenetic glucoside, in the roots. The varieties are therefore generally distinguished as 'bitter' and 'sweet' according to the presence or absence of this principle. The former cannot be eaten raw on account of the poison, and can be eaten with safety only after boiling them in water. Varieties are distinguished by many local names such as Red Brazilian, White Brazilian, Singapore and Mauritius (in Malaya) which mature in 8, 9, 15 and 18 months, respectively. In South India we have the 'Travancore Red', which is a tall variety somewhat drought resisting, and yielding roots which are said to have a fine taste. The 'Travancore white' is a shorter variety, late maturing and yielding roots which are less fibrous and more sweet than the red variety. A newly introduced variety which is said to excel these is called the 'butter stick', and is now coming into cultivation.

Chemistry and uses.—The poisonous or bitter principle in the roots of the bitter varieties is due to the presence of a glucoside and also an enzyme which can decompose it and liberate the highly poisonous substance hydrocyanic or Prussic acid. The latter is present both as such and more largely in combination as the glucoside. When after harvest the roots are stored, and begin to wilt, the acid is liberated. The poison is present more near the cortical layers than in the interior of the roots. Roots which are firm and have a somewhat yellowish flesh contain more of the poison than the softer kinds with white flesh. The presence of the acid can easily be made out by the characteristic smell. The enzyme is destroyed on boiling the roots, and the hydrocyanic acid is also dissolved out by the water. Frying the root slices destroys the poison more thoroughly. As a measure of safety, it is necessary that all kinds of roots whether called bitter or sweet are boiled before use, preferably also with the skin grated off and removed.

The starch content of the roots varies within wide limits from about 16 to 26 per cent on the fresh weight. Even 40 per cent has been recorded. The following is the composition of a sample of fresh tapioca root:—Moisture 59·4, proteins 0·7, fats 0·2, carbohydrates 27·0, fibre 0, and ash 1·6 per cent (Aykroyd).

The roots may be used for consumption in different ways. They can be used as a vegetable like potatoes or sweet potatoes, after boiling. They can be cut into thin slices after cleaning off the skin, boiled moderately, and then dried in the sun and stored. These chips can be fried and eaten like potato chips or

ground into meal and eaten like porridge or converted into other dishes. For storage both dry chips and flour are suitable; the latter is however better because the meal is not attacked as much by weevils as the chips.

Tapioca Flour.—The pure starchy flour prepared from the roots goes by the name of tapioca or, when it is made somewhat crudely, by the name of cassava. Tapioca flour can be prepared from the roots on a domestic scale in the following way;—Peel or scrape the skin off and wash the roots clean. Grate the roots into a fine meal; tie up in a bag of clean strong muslin cloth; knead it well in water in a clean vessel. The starch will now pass into the water like a stream of milk, while the impurities will remain inside the cloth bag. Repeat the kneading with fresh charges of water until no more white material passes through and the water comes out clean. The smooth white layer of starch settles to the bottom of the vessel as a thick sediment, from which the clear water is separated by decanting it off. The wet starch is now dried in the sun and then on a hot plate. On a factory scale the operations are all carried out by means of suitable machinery. The starch is put into the form of pellets and flakes and torrified on hot plates, giving the 'pearl' and 'flake' tapioca of commerce.

SECTION VI.

CONDIMENTS AND SPICES.

I. PEPPER.

VERNACULAR NAMES FOR PEPPER: *Kannada*—MENASU; *Tamil*—MILAGU; *Telugu*-MIRIYALU; *Malayalam*-KARUMILAGU, NALMILAGU; *Hindustani*—KALIMIRICH.

Pepper—Piper nigrum—or black pepper is the product of the pepper vine, which is a perennial climbing plant cultivated as a permanent plantation crop. It is cultivated as a pure crop on a plantation scale, as a mixed crop along with coffee or oranges on a large scale, and in arecanut gardens with the areca trees themselves as standards for the vines to climb on, and on a small scale in cottage gardens either by itself or along with mango, jack or cocoanut as a mixed crop. In addition to the cultivated crop, considerable pepper is gathered from forests where it grows wild.

Distribution, climate.—Pepper is closely allied to the betel vine—Piper betle—but unlike the latter which is very extensively grown over a very wide range of conditions of soil, climate and situation, the cultivation of the pepper vine is confined to a very narrow range. It is only along the Malabar coast and extending inland to the cultivated zones on both sides of the Western Ghauts from the districts of Konkan and North Kanara in the north to Travancore in the south that it flourishes in India. Travancore and Malabar have been the important countries of cultivation from very ancient times and still continue to be the largest sources of production. Outside of India its cultivation is of importance in Ceylon, Malaya, the Islands of the East Indian Archipelago generally, and chiefly in Sumatra, Java, Borneo and Siam.

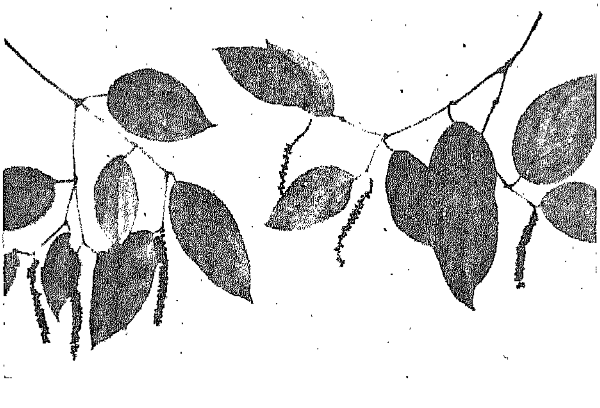
It requires a fully tropical climate and a heavy rainfall of at least 60 inches and a humid warm atmosphere such as is to be found amid the luxuriant vegetation of these regions. The crop stands a fairly wide range of temperature, as the average of the daily maximum in these regions may go up 100° F. and the minimum to an average of 60° F. with about 50° F. as the lowest. It requires the shelter and shade of well wooded situations. As regards altitude, pepper can be grown from sea-level up to elevations of even 4,000 feet.

Soils.—The soils on which pepper is grown are the red loams and sandy loams overlying the decomposing gneisses and largely lateritic in type, of the kinds which comprise the hills, valleys and foot hills of the Western Ghauts of which the coffee and tea estates of the hill slopes and the areca gardens of the plateaus are largely composed. In the coastal belts where the river bank soils are sandy and alluvial and cocoanuts form the principal crop, pepper is not generally grown and soils higher up and more of the loams and clayey loam soils are preferred. In the Islands of the East Indies, the soils are more open but consist of exceedingly fertile and volcanic rock debris, compared with which these ancient formations in the Indian pepper tracts would be considered very poor and depleted. Pepper is grown in situations where there is no of lack of drainage, on the slopes and elevated levels. In the arecanut gardens where it forms an important mixed crop, elaborate arrangements are made for the drainage of the heavy rainfall, by means of a very efficient system of layout suited for thorough drainage.

Starting a Pepper Garden.—As the pepper plant is a climbing vine, supports or standards have to be provided for the plants to grow on. Where a pepper garden is to be started solely for the cultivation of pepper, arrangements have to be made first for these standards. The standards are provided generally by quick growing straight-stemmed trees planted for this purpose. The trees selected for this purpose are the 'dadap' or 'Erythrina indica', and the silk cotton tree or 'Eriodendron anfructuosum.' The straight growing shade tree, silver oak—Grevillea robusta—planted generally as shade in coffee estates will also serve the purpose. Sometimes dead wood poles are used and even stone pillars, but these are rare. As temporary standards poles of wood or bamboo can be put up which will serve during the time that the permanent live standards are growing and can be replaced when the latter have grown to sufficient height and girth. The pepper is a shade loving plant and though the systematic and heavy shade of the kind found necessary for coffee is not needed, a few good shade trees here and there in the garden are found beneficial and should be provided. The gardens also need shelter against high winds and good sheltered valleys protected on the south-western side should be selected or in the alternative a suitable belt of trees as a wind break should be provided. In pure pepper gardens the vines are in groups under standards which are about 8 to 10 feet apart each way. After the site has been selected and the ground cleared, pits are dug for the planting of the standards at the above distance apart. These eventually serve for the planting of the pepper vines also. Standards are planted either as straight branches or as seedlings from nurseries raised specially for the purpose. The planting should be made in the months of April to May, in the early rains, in pits which have been dug at the close of the rains in

Pepper vine grown in Arecanut gardens, trained on Areca trees as standards. [Mys. Agri. Dept.

Pepper vines in Coffee Estates in the midst of coffee and cardamoms, trained on the shade trees as standards. [Photo by Author.



Pepper vine branches showing how the ripe berries are borne. [Mys. Agri. Dept.

the previous October and left to weather during the subsequent months. Planted in this manner the standards make enough growth to allow of pepper being planted in the month of August or September, about the time that the heavy rains are abating and coming to an end.

Pepper is however more largely planted as a mixed crop in plantations of coffee or oranges, and in areca gardens. The shade trees in the former and the areca trees themselves in the latter form the standards and the planting of standards as such is therefore not necessary. Pepper may be planted thick or thin, as suits the fancy of the planter. In some cases practically every one of the shade trees carries a group of pepper vines and in others only varying proportions of the shade trees are used for pepper planting. The same is the case in areca gardens, where a larger or smaller number of areca trees have pepper vines trained on them. In coffee or orange estates where the silver oak trees are usually about 24 feet apart each way, if every one of the silver oaks is planted to pepper then the estate should be considered a fully planted pepper estate although the number of pepper clumps at this rate will amount to only 70 per acre. Areca gardens contain at least double this number, as most of the trees exceeding the 30 year age group have pepper vines on them, when it is considered fully stocked with pepper. Pure plantations have of course a much larger number still, which may amount to 300 or more per acre according as it is thickly or thinly planted.

Cuttings for Planting—The planting material for the pepper vines is furnished by cuttings of the vines, each about two to three feet long and these are planted at the rate of four or more to each standard, according to the size of the tree selected as standard. A great deal of care is required in getting the cuttings necessary for planting. Very often cuttings are obtained in cartloads from places where they may be available without any inspection of the parent vines from which they are cut or any guarantee that they have been taken from selected vines. The result is sometimes very disappointing, because when the vines grow and begin to bear many of them are found to be unsatisfactory.

In selecting vines to obtain cuttings from, it will be useful to note the following characteristics of the pepper plant. Pepper plants bear flowers which are pistillate (female), staminate (male) or bisexual (containing both stamens and pistil). These different kinds of flowers are borne on different vines so that the vines may be classified as male vines, female vines and hermaphrodite vines. In the last kind of vines every flower is fertilised and sets fruit (normally) and the inflorescence grows into a well filled bunch of pepper. Other things being equal, such as length and number of inflorescences, size of the fruit and so on, this kind is the best one to obtain cuttings from. In the second kind of vine, *viz.*, the female, cross fertilisation has to take

place before the fruit can set; this is sometimes complete and sometimes only partial and in the latter case the bunch is not so full as it should be and many blanks are to be found. For the same length and number of bunches therefore the produce of the hermaphrodite vine is larger and more certain than that of the female vine. In the male vine, no fruit sets at all as the flowers are all male. At the flowering time these male vines are the most showy in the garden, the inflorescences are long and many and the vine looks as if clothed with strings of cream coloured beads, when the anthers are open. Within a few days however the inflorescences all wither and drop off. By the uninformed these vines are taken to be the most prolific and when within a few days every one of the inflorescences sheds and the vine looks completely bare it causes no little disappointment. Such vines have therefore to be scrupulously avoided for obtaining cuttings from. Anything more than a bush or two of such vines for a large garden has to be guarded against.

If cuttings are obtained from one's own garden or plantation, for extension or replacement, they should be taken from vines which have been previously noted as belonging to the hermaphrodite class and the best performers. If not, then the gardens from which cuttings are proposed to be got should be inspected in the crop season and the good ones marked for taking cuttings from. Where large numbers of cuttings are required and large areas have to be planted in a single season it may not be possible to ensure cuttings from the best vines but it will be a safer plan in the long run to be sure of the quality of the cuttings and spread out the planting programme over two or three years rather than speed up planting with the risk of low yields permanently. It may be possible sometimes to get selected vines in certain gardens for cuttings and in such cases these vines should be made to give as large a number of cuttings as possible by reducing the length of the individual cuttings. The best method of ensuring a permanent and satisfactory means of obtaining good supplies of good cuttings is to plant and maintain a good nursery area where only choice cuttings should be planted, and the planting done in such a way that each clump or group will consist of cuttings derived from one single plant. This will ensure further purity in the parentage of the cuttings to be taken eventually from these clumps for planting out.

Rooted Cuttings.—Planting material may also consist of rooted cuttings. These are obtained by having a small nursery in which surplus cuttings are planted and made to root; when much pruning is being done and there is no immediate demand for cuttings for planting, then the prunings are cut into short lengths and put down in a nursery to root, so that they can be made use of for planting when occasion arises. It will be advisable to have such a nursery handy, so that blanks may be filled with good rooted cuttings which will catch up with the cuttings planted

first. As a matter of fact when cuttings are got out from far-off places for planting, a large number fail to strike root. Thus out of 2,000 cuttings got out from Malabar and planted in the Mysore Government Farm at Marthur, only 150 cuttings or 7·5 per cent struck root. Similarly out of another 200 supplied to a private farm only 30 cuttings or 15 per cent struck root, even though in both cases the transport was by quick motor lorry.

Rooted cuttings can also be secured by means of layering the branches from a growing vine. This is specially recommended for obtaining rooted plants from choice varieties or selected vines and from good bearing branches; the rooted layerings from the latter begin to bear earlier than plants raised from ordinary cuttings. The method is somewhat laborious, but is quite worth while for obtaining specially good plants which will bear within the first two years after planting. Where extensions and new plantings are being made in one's own garden and large numbers are not required at one time the method can be adopted without difficulty. Such cuttings will begin to bear in the very first season after planting, but as in the case of budded or grafted plants they should be allowed to make good growth and become well established during a period of two or three years before being allowed to bear crops.

Propagation by Layering.—The layering of the vines is carried out in different ways. The layering can be made either in the ground or in special receptacles. The branches of the vines, if they are sufficiently low, can be laid flat along the ground under the vine and staked down at suitable lengths. The nodes in contact with the ground take root readily and when the rooting is sufficient, the rooted lengths can be severed from the parent vine and carefully removed each with a ball of adhering earth to protect its roots. In another method, the growing end of the layered branch is made to grow upright on a short length of stick planted close by, on to which the vine is tied. When the branch has rooted well, it is removed from the ground with a ball of earth adhering to the root and the vine growing on the stick. Instead of making the vine root on the ground, it can be made to root in soil kept in special receptacles such as shallow baskets or bamboo hollows split lengthwise into two halves or in areca sheaths. Baskets used for this purpose are 18 inches in diameter and some 3 inches in depth and are made of bamboo or brushwood. Even the husks of cocoanuts, if they can be had of the suitable size, can be used. The bamboo hollows are 4 inches in diameter and 18 inches in length. They are sawn across close to the node and then split into two halves along the length, giving thereby two semi-cylindrical hollows suitable for layering in. The branch to be layered is placed flat in the basket or bamboo hollow with the rooting node resting on and covered over with moist earth. In the case of the bamboo hollow, the growing end of the vine is made to point towards the node or

septum end of the hollow. After the vine strikes root and is severed from the parent branch and when it is ready for being planted in its permanent place, the rooted cutting with the whole of the soil can be slipped into the hole prepared for it and the bamboo hollow withdrawn carefully to be made use of again.

The branches of the vine from which layerings are to be taken are the ones which grow near the base; they grow to great lengths and usually straggle along the ground, often being trodden on and damaged. When it is proposed to make use of them for layering, they are carefully rolled up and made to rest upon the fork of a branched stick planted in the ground near the vine, to be taken down and laid flat for layering in one of the ways described. Another method of obtaining rooted plants is to 'marcot' the vines. A lump of moist soil about the size of a small fist is put round the node, covered over and kept in position by tying over it a piece of cloth, gunny or other material. The node develops roots quite readily inside this lump of earth in the season, and the rooted vine can then be severed from the parent vine below the marcotted portion and made use of for planting. Layerings are also made from branches growing higher up; in fact considerable cutting down or pruning will often have to be done in order to keep the vine within a convenient height and at that time much material is avilable for layering. In such cases some kind of scaffolding will have to be put up, carrying a rough platform on which the baskets or bamboo hollows can be kept and the vine layered.

The season for layering the vines is during the south-west monsoon when the vines root at the nodes very readily. Put down to root in the months of June to July, the rooted plants will be ready for severing and putting down in their permanent places by the end of August or the beginning of September.

The layerings so far described are from vegetative branches whose length has to be kept down or of which there is too large a number. These cuttings whether rooted or otherwise when planted and well established take the normal period of four years to come into bearing. Sometimes it may be possible to layer the fruiting branches themselves, such as, when an areca standard is blown down. In such a case, a large number of fruiting branches becomes available for layering and the pepper bush which may otherwise go to ruin can be turned to good account. Layerings from such branches come into bearing in the very first season after planting; but they should not be allowed to crop for two seasons, so that they may establish a good root system and attain considerable growth of vine above ground.

Seedling Pepper.—The pepper plant can be propagated also by sowing seeds and raising seedlings. For this purpose, fully ripe berries are collected in the month of April, at which time they are largely available. These fruits are put into water and

soaked for a night. They are then mixed and rubbed with a paste of cowdung and then sown in a nursery. The nursery is kept regularly watered. In 30 days the sprouts begin to appear here and there and in another fortnight they are all fully germinated and will grow into plants fit to transplant in July and August. The progeny will be of a mixed character, as the pepper is a cross-fertilised plant. The method is therefore not to be recommended for the ordinary grower.

Planting the Vines.—The planting of the pepper vine whether of rooted cuttings or fresh unrooted cuttings is done in the month of July. The pits are made preferably on the north and north-east sides of the standard, so that the damaging effect of the severe western sun may be avoided. Pits are dug about 18″ deep and 18″ broad and 2 or 3 feet long in a somewhat semi-circular form below and around the standard and are filled about one-half with good jungle soil. In the case of unrooted cuttings, from three to six or seven cuttings are planted in each pit. This large number is really quite unnecessary but they are put in, because a large number often fail to strike root. If the cuttings are good and most of them take root then those in excess of two vigourously growing cuttings may be removed and used for filling blanks, where necessary. The planting is so made that about 18″ of the lower end of the cutting lies slopingly over the earth in the pit, the upper portion of 18″ or more being made to rest on the bole of the tree or other standard employed. The pit is now filled with more jungle soil and pressed round well with the hand. Water should not be allowed to collect near the base of the tree and the earth is heaped up like a mound and not formed into a basin as is usual with other plants. After planting is finished the cuttings can be seen to lie in a semi-circular row about 2 to 3 inches from each other around the base of the standard with the upper ends resting on the standard like the prongs of a fork. In the case of rooted cuttings, the pits are made smaller in length, and are filled to the level of the ground. One or two cuttings are planted in each pit, the plants being put in without disturbing the earth round the roots, and the basket or bamboo hollow in which the cuttings were rooted is carefully withdrawn. The planting is just deep enough to cover the roots and one node of the vine above the rooted node or nodes. The soil is firmly pressed and soil heaped up a little, so as to prevent water from collecting. The growing end of the vine is then lightly tied to the standard to keep it in position.

The pepper plant makes rapid growth and at the end of the first year may be four or five feet long. As the vines grow, they have to be tied to the standard usually at intervals of one foot. In some countries, the custom prevails of lowering the vine after one year or eighteen months, coiling it round and burying it in the ground round the standard, all but a short length. More shoots come up after this operation and a larger root system is

developed adding strength to the vine. This practice is not adopted in Mysore, though in the case of the betel vine, it is a regular annual operation and is very general.

Care and after-cultivation.—The vine is generally allowed to grow only one main stem, the lower portion of which is kept clean and unbranched, up to a height of some three feet. As the vine grows it branches profusely and grows in height almost at the rate of five feet every year. In the course of four years the vine begins to bear its first crop. The annual operations in the meanwhile are the regular tying of the growing vine and the annual cultivation and manuring. The tying up becomes however unnecessary later on, as the vine sends roots from the nodes which grip the standard firmly, especially where the standards are trees with rough barks. Pepper gardens are dug and manured in the month of April sometimes after the picking of the year's crop is over. In areca gardens, the pepper is not specially manured but shares in the manuring given to the areca trees on to which the vines are trained. The manure usually consists of cattle manure of the kind common in the malnads, that is to say, with a large admixture of well rotted green leaves. About half a basket (or head load) is applied to the trees and covered over with good fresh earth from the jungle. Another yearly operation is the lopping of the tops of the standards where these are Erythrinas or other specially planted standards. The standards are topped and branches removed, so as to keep them within a manageable height well adapted for the vines to climb on. The vines themselves are also trimmed at the top and prevented from growing too tall for convenient picking. Both these operations are done by the pickers at the time of gathering the crop.

Pepper Harvest.—The pepper vine begins to yield its first crop normally after it is four years old from planting, but good crops can be obtained only after six or more years. The vine begins to flower from about the middle of July. The ripe berries become ripe and ready for picking from the middle of the following February and the harvest goes on until the middle of March. When quite ripe the berries assume a beautiful orange colour and as soon as a few of this kind are seen here and there in the garden the gathering of the crop begins. The pepper bush is allowed to reach a height of even twenty feet, so that a good proportion of the crop is borne above a man's height. For reaching the clusters at this height ladders have to be used and either regular step ladders or bamboo poles with the branches cut short to a stump each of which then serves as a step, are used for the purpose. Pepper is gathered by snipping off the whole of the spikes or catkins or clusters with the berries. These clusters of berries are now brought to the house and are spread on a mat or clean floor and rubbed between the hands or trampled over, in order to free the berries from the stalk. In

large estates, threshing floors with a smooth hard floor are provided on which the clusters are spread and rubbed or trampled on and the berries freed. The berries are then spread out to dry in the sun. In six days of bright sun, the pepper becomes quite dry; the green outer skins become black and slightly shrunk, due to which the berry assumes the familiar wrinkled appearance of the ordinary pepper corn, or pepper of commerce. This article sometimes goes by the name of black pepper also. It is in this form that pepper is generally marketed.

White Pepper.—There is also another product which goes by the name of 'white pepper', which is made in the following manner:—For this purpose, pepper is gathered at a slightly advanced stage of ripeness, *i.e.*, when a very large number of berries are turning yellow. The bunches are brought to the house and are heaped up for a day or two until all the berries become yellow. The berries are now separated from the stalks and are put into water to soak over night. They are taken out in the morning and are heaped up and covered over. The berries heat up a little and undergo slight fermentation and in this stage the outer skin can be easily rubbed off. When this stage is reached the berries are taken from the heap, and put into water and rubbed between the hands. The outer skin and the pulpy layer immediately below it are loosened and are easily rubbed off, leaving the berries white and clean. These are then put out in the sun and dried thoroughly, the resulting product being the 'white pepper' of commerce. White pepper is generally made for the domestic use of the grower and to a small extent for the trade.

Yield.—The pepper plant begins to yield a full crop only after the sixth year. The yield from the vines is exceedingly variable, both on account of the different varieties and strains that usually comprise a garden and on account of the seasonal variations. Over a large area about 2 lb. of cured pepper per bush should be considered a good average yield, 3 lb. per bush will be a good yield per bush over a large area. Individual bushes however give surprisingly heavy yields and where a bush consists of several vines growing on a tree like a mango or jack as much as 12 lb. have been gathered. Many bushes of even ordinary dimensions are known to produce 7 lb. each under favourable conditions. Generally yields are uncertain and depend a good deal upon the distribution of the rainfall. In a garden planted 12′ by 12′ and consisting of approximately 300 bushes per acre the yields were reported to have varied from 1 lb. per bush to 5 lb. per bush in the different years. In some years the crop may amount to almost nothing; in a thirty-acre garden in one year the crop amounted to only 210 lb. In areca gardens which are well stocked with pepper the yield may go up to 75 lb. per acre.

Ripe pepper after harvesting and separating from the stalks loses on drying only about 25 per cent of its weight; 100 lb. of

green pepper yielding 75 lb. of dry pepper. By volume it loses only 16 per cent, 100 seers of green pepper giving 84 seers of dry pepper. If pepper is of good quality, the berries being well filled and heavy, then an imperial bushel of such pepper will weigh 47 lb. and a Mysore seer will weigh 1·7 lb. White pepper is heavier and a Mysore seer of white pepper will weigh 2 lb.

Botany and Varieties.—The pepper plant belongs to the natural order 'Piperaceae' and is distinguished botanically by the name 'Piper nigrum'. It is closely allied to the common betel vine, 'Piper betle', the 'pippili' vine—'Piper longum'—and the tailed pepper—'Piper cubeba'. These are all climbing evergreen plants, with jointed stems, generally rooting at the nodes on the stem. The leaves are from light to dark green, smooth and entire; in shape they are broadly lanceolate, but many variations exist due to the difference in the proportion of the width to the length, according to which they can be classified, broad, medium, and narrow leaved, and also as long and short. The stems grow upwards, clinging to the tree or standard on which they grow for support, and reach a height of some twenty or thirty feet. They branch horizontally from the nodes but these do not attain much length. Full grown bushes envelop the standard all around in the form of a dense growth about four or five feet in diameter. The inflorescences which later on become the pepper clusters are slender catkin-like spikes which vary according to the varieties from about two inches up to nine inches in length, hanging gracefully downwards, generally straight but in some varieties slightly curved, across the middle. The flowers are both unisexual and bisexual, and these are borne on different plants. Plants are therefore either male, female or hermaphrodite. Occasionally, a female inflorescence may have one or two hermaphrodite flowers also but this is very uncommon. The flowers are naked and are small and inconspicuous being of a dull white colour. When the pistillate flower is open, the little ovary is surmounted by a five branched stigma which looks like a five-cornered little star. In the perfect flowers the stamens which are two in number are to be seen on either side of the ovary and are very short and inconspicuous; they persist at the bases of the ripening fruits as two little dark brown specks. In the male plants the inflorescences are generally very numerous and these pendulous spikes look very ornamental. These spikes drop off after they have remained open for a few days. The flowers are all cross-fertilised; even in the hermaphrodite flowers the stigmas become receptive, long in advance of the opening of the anthers and are really dry and brown at the latter stage. There is considerable unevenness in the fertilisation of the flowers with the result that the spikes are seldom completely filled, nor are all the fruits in the same stage of ripeness. The fruit is an one-seeded berry. Fruits take about nine months to

become quite ripe and at this time they change colour from dark green to deep orange or red. In some varieties these berries drop down when they are ripe, but in most varieties it is the whole spike that drops. The spikes contain from 20 to 80 berries according to the variety.

There are several varieties of cultivated pepper which are distinguished by local names. The following varieties are grown in the Mysore Malnad :—

Wokala Morata.—This has longish and light green leaves ; it is only a moderate bearer. The spikes are short about 2½ to 3 inches long and the berries are also few about 20 per spike. The ripe berries change from green to deep orange and then coral red. The berries shed at the ripe stage and have to be gathered just when one or two are becoming orange. The berries are large and are fancied for making 'White Pepper'. This is also the earliest to be harvested. The flowers are female.

Kari Morata.—This is a modest yielder, but crops uniformly every year. The spikes are short and curved, about 2 to 2½ inches in length generally well filled. The berries are rather small and dark green in colour. The ripe fruits are red in colour and they do not shed. The flowers are female.

Arisina Morata.—This is very much like the Kari Morata but differs in the colour of the ripe berries which are yellow (hence the name Arisina which means turmeric-like or yellow).

Doddaga.—This is a broad-leaved variety ; the spikes are about 3 inches in length and curved. The berries are the largest among the different varieties and are red in colour when ripe. The flowers are female. The variety is much esteemed for making white pepper.

Malligesara.—This is a large-leaved variety ; it is one of the best yielders. The spikes are about four inches in length and well filled. The berries are rather small, are red when ripe and do not shed. The flowers are female.

Tattisara.—This is also a good yielder, has narrow long leaves very dark green in colour, and the spikes are four to five inches in length. Ripe berries are red in colour and somewhat larger in size than in 'malligesara.' The leaves drop largely when the berries are ripening and this is the characteristic of this variety. The flowers are bisexual.

Kalluvalli.—This is one of the best varieties and comes from Malabar. The leaves are somewhat longish, the spikes are long being about up to nine inches in length in good specimens. The berries are medium in size and become red when ripe. The flowers are bisexual.

Balamcota.—This is another of the good varieties from Malabar. It is somewhat broader-leaved and has long and well filled spikes. The berries are slightly smaller than in Kalluvalli. They turn red when ripe. The flowers are bisexual.

Cheriakodi.—This is also a Malabar variety. The berries are very small. The flowers are female.

In Malabar, many named varieties in addition to those listed above are recognised, some of which may be found to be the same as the Mysore ones, though with a different local name. These are Thulakodi, Chumela, Kothanadan, Arikothanadan, Mundi—all of which are good yielders and yearly bearers; Karuvalli and Karinthakara are good varieties but bear in alternate years.

Wild Pepper.—Considerable pepper is gathered from the 'Kans' or forests in which the pepper vines grow almost wild and without any attention. These are vines which have grown from seed fallen from older vines or from vines straggling on the ground rooting promiscuously and climbing and growing on the nearest tree. Crops from these are gathered by pulling down the vines or by breaking off the bunches, an operation which seriously damages the vines. The point of interest about these is the variation which can be seen in their characters such as shape and sizes of the leaves, the length of the spikes, the number and size of the berries, the bearing habit and so on. Some vines are seen to bear berries in all stages from just opening flowers up to ripe berries ready to pick. Spikes are generally very poorly filled but berries were come across quite three or four times the size of the ordinary pepper, the largest seen being $\frac{3}{10}$ inches across. In others the berries are conical in shape with a broad base and a pointed tip. The produce from the jungle is often light or hollow. In the case of the large-berried variety seen, very little of the pungency of the ordinary pepper was present.

Pests and Diseases.—A somewhat serious insect pest of pepper is a berry-eating grub which bores into and eats the contents of the ripening berries, rendering them hollow. The pest is the larvæ of a flea beetle—*Longitarsus nigripennis,—M.*—which is a yellow and blue beetle very minute in size and jumps about like a grasshopper. The female beetles lay eggs singly in small depressions made in the rind of the young berries. The eggs hatch in a week or ten days into small pale yellowish grubs which bore into the berry, eat the contents and pass on to bore into and destroy another in the same way. Each grub may destroy two to three berries. The larvæ become ready to pupate in a month and at this stage drop down and pupate inside the soil at the base of the vines. There is also considerable shedding of the whole bunches which accompanies the damage to the berries, which is partly at least due to the attack by the beetle larvæ. The pest is said to have increased in recent years in North Malabar and Wynaad, where the damage has become serious.

As a preventive measure, it is recommended that the soil under the vines should be regularly and thoroughly hoed or

stirred and all pupae found therein should be destroyed. As a control measure spraying with Bordeaux mixture is found useful; it acts as a repellent against the beetle and also as a fungicide killing the fungus which is one of the causes of the shedding of the bunches of berries. Pepper is also subject to the attacks of several scale insects, *viz.*, (1) *Lepidosaphes piperis*, G., (2) *Lecanium marsupiale G.*, (3) the mussel scale *Mytilaspis piperis*. Though in bad cases these scales infest the leaves and stems of the vines in myriads, suck the sap and may even dry up the vines, they are seldom found to any large extent. Badly infested parts of the vines should promptly be pruned off and burnt. Spraying with insecticidal soap washes is also effective as a control measure.

Sometimes mealy bugs also become a serious pest, especially when the rains of the north-east monsoon are poor and also when the vines have been sprayed early in the season with Bordeaux mixture for the checking of spike shedding. This fungicide kills at the same time the fungus which keeps the mealy bugs in check.

The most serious disease of the pepper vine is the "wilt" disease which at one time appeared as an epidemic and destroyed innumerable vines and caused wholesale ruin of extensive pepper areas. The outbreak appeared about fifty years ago, spread rapidly in Mysore, Coorg and Wynaad, and Malabar where the effect of the ruin was almost permanent and pepper cultivation came to a stand-still for many years thereafter. The disease however abated later on and for many years now it exists only here and there and has not spread. The destruction caused is a drying up of the whole vine; fine well-grown bushes in full bearing covering thickly large tree trunks up to a height of twelve or fifteen feet succumb to the disease; the leaves yellow, droop and then dry up and then the whole vine dries up and dies. The disease is said to be a kind of "stump rot" and the remedy recommended is to isolate the vine and the root of the tree forming the standard by means of a trench and thereby prevent it from spreading. This however is not of any practical value as the disease breaks out over large areas and the number of vines to be treated becomes too many to manage. It has been suggested that the only satisfactory remedy lies in the discovery or evolving of varieties resistant to the disease.

The spikes and berries are also attacked by the fungi "Colletotrichum spp." which cause them to shed; the attack can be controlled by spraying with Bordeaux mixture.

Chemistry and Uses.—Pepper is one of the most valuable of the spices. It is an indispensable ingredient of sauces, soups and curries, forming part of the daily food of the world's population and specially so of the oriental countries. It is one of the most important ingredients in most Indian medicines, in fact it is one leg of the "tripod"

of three drugs on which every Hindu medicinal preparation is said to rest as the foundation.

As a carminative, pepper owes its properties to three important constituents, *viz.*, a volatile oil, a resin and an alkaloid 'piperine'. These are contained both in the skin or pericarps and in the hard coated seed which it encloses. White pepper has less flavour and less pungency than black pepper, for the reason that the outer skin which also contains some of these ingredients is removed. The volatile oil content varies from 1 to 3 per cent, and the alkaloid from 5 to 8·25 per cent. The volatile oil belongs to the class of terpenes. Much of the pungency of the pepper is due to the resin, and part to the alkaloid. The endosperm is composed of aggregates of starch grains of peculiar fine-grained shape, a feature which is taken advantage of in detecting adulteration in commercial ground pepper. Pepper (pepper corns, black) has the following chemical composition in respect of the plant food ingredients.

Nitrogen.—1·80 per cent, P_2O_5: 0·35 per cent, K_2O: 1·32 per cent, CaO: 0·70 per cent and MgO : 0·06 per cent.

Production and Trade.—The area under pepper in South India including the district of North Kanara (Bombay Presidency) is approximately 110,000 acres.

The Indian trade in pepper comprises both exports and imports of considerable magnitude. The export during the year 1939-40 was 18,675 cwts., of the value of about Rs. 4 lakhs. The export at one time was very much more and amounted to about 25,000 cwts. India imported pepper in the year 1939-40 amounting to 142,344 cwts., valued at Rs. 19 lakhs. In former years the imports were much lower; thus in 1937-38 it was only 20,150 cwts, and in 1938-39 was 24,050 cwts.

II. CHILLIES (Capsicum annuam).

VERNACULAR NAMES FOR CHILLIES :—*Kannada*-MENISINAKAYI, *Tamil*-MILAGAI; *Telugu*-MIRAPAKAYA; *Malayalam*-MOLAKU; *Hindustani*-MIRCH.

Chillies, also known as Cayenne pepper or red pepper, form an important condiment crop grown in India and especially so in South India where it is grown very extensively. The chillies used as condiment are noted for their pungency and give the South Indian dietary its peculiar and outstanding characteristic. At the present time, chillies are such an indispensable and common ingredient in South Indian food at every meal that the quantities consumed in ordinary homes are surprisingly large. Notwithstanding such a general use at the present time the crop is not indigenous to India where prior to its introduction the black pepper was being used for affording the necessary pungency to the condiments. The native home of the crop is

considered to be Brazil and the South American continent in general and its introduction into India is said to be due to the Portuguese. The wide popularity and the extensive cultivation of the crop are probably due not only to its much greater pungency but also to the fact that it can be cultivated as an ordinary field crop of a few months' duration with great ease over a wide range of climate and country in contrast with black pepper which can be grown only in special localities and with much difficulty. The partiality of the people of South India for the condiment is, however, not unique as the native races in many parts of the tropical world notably in South and Central America and in South, Central and East Africa are stated to consume incredible quantities. It is certainly surprising that the human tongue and digestive system can bear the hot blistering taste of the chilli but it must be stated that the taste is always tempered by various mixtures in the food and practice does the rest.

Chillies have a wide range of cultivation, being grown under both tropical and sub-tropical conditions. As already stated its home is said to be in Brazil and in that country and throughout most South American States it is grown and consumed. In Mexico and Central America likewise the crop is grown and used. In the Southern States of the U. S. A. some of the less pungent species are grown largely. Throughout the African continent, in Spain and in all the Asiatic countries generally Indo-China, China and even in Japan chillies of one or other of its many species are grown. The plant grows over a wide range of elevation from sea-level up to elevations of 5,000 feet. Grown as a rainfed crop it can be grown in tracts with a rainfall of about 25 inches up to 50 inches. Heavier rainfall during the growing season such as occurs in the malnads is not favourable as it leads to the rotting of the leaves and the fruits; but even under such conditions the crop can be grown if planted somewhat after the heavy burst of the monsoon is over, for instance, about the end of August. In tracts of low rainfall, the crop is grown under irrigation as likewise when grown as a hot weather crop. The crop can be grown in both the rainy season commencing from about June and also in the hot weather commencing from about February.

Soils.—The soils suited are the well-drained fertile soils of the somewhat heavy loam type. Good deep soils are required free from grit, gravel and stones. It can be grown to perfection on the ordinary red loams with good manuring, on the black cotton soils and on the somewhat clayey loams under tank irrigation such as are put under rice, which are however free from waterlogging. On the sandy or light alluvial loams also very good crops can be raised under heavy irrigation and manuring. Drainage is very important as the plants begin to shed their leaves and otherwise to sicken in badly drained situations and where water may collect or stagnate even temporarily. It is a

typical garden crop and requires and responds liberally to good cultivation, manuring and irrigation.

Rotation —Grown as a purely rainfed crop chillies are rotated with a variety of dry crops, but generally with a grain crop like ragi or jola with the usual leguminous crop mixtures. Groundnuts and horsegram or horsegram alone, castor, or cotton are also selected to follow chillies in the rotation. Grown as a rainfed crop chillies form the only crop of the year as it occupies the ground for some five or six months and the field has to be prepared thoroughly in the preceding months. When grown as an irrigated crop chillies are rotated with one or other of a variety of crops. Sugarcane, turmeric, beans and other vegetables, irrigated ragi, chrysanthemums and maize are all crops from which a selection can be made. Very often potatoes and brinjals are also included, but this is not a safe rotation as the diseases peculiar to the one also attack the others and as the soil becomes infected and thereby passes the disease on to the succeeding solanaceous crop. This is especially the case with the bacterial disease called the 'ring' disease of the potato.

Cultivation.—The preparation of the ground for rainfed chillies begins with the first rains in the months of May and June. The field is ploughed after every rain three or four times and is then worked with the toothed or bladed harrows to break the clods and bring up and gather the roots of stubble and weeds; these are then collected and burnt. Cattle manure is carted at the rate of twenty cartloads per acre and worked in with the plough or harrow and the field is brought into a condition of clean and fine tilth. These operations can be considerably simplified by the use of the improved plough and the six shovel cultivator which will work more expeditiously and produce a deeper tilth. The field is made ready for the planting of chillies generally by about the middle or end of July when the rains have set in steadily and enough moisture is available in the soil for the transplanted seedlings. Deep furrows are now ploughed at distances of two feet from each other both along the length of the field and across, so that the field is laid into two feet squares. In the intersections of the furrows a handful of cattle manure is put in and the seedlings of chillies—which are raised earlier in a separate nursery—are planted singly or in two's. The seedlings if they have grown rather tall are topped before being put in. The planting distance is sometimes varied by ploughing the lengthwise furrows three feet apart and planting the seedlings 9 inches to one foot apart in the furrows. The seedlings are planted slightly to one side of the furrow, for the better retention of the rain water. Usually the rainfall about this time is frequent enough to enable the seedlings to establish themselves quickly, but otherwise they receive a set back, the result of which is not got over and the yield of the crop suffers. If the area planted is not large a little hand watering is given, water

being carted in a barrel or large vessel for the purpose. Soon after the plants start making new growth the rows are intercultured by means of bladed or toothed hoes of the proper width. When the crop is planted in two feet squares it is possible to work the same hoes both along and across the field. The hoeings are repeated twice at intervals of two weeks and the field is then hand-weeded to keep the ground under the plants free from weeds. About the same time it will be well if a small dose of oilcake manure—either groundnut or 'honge'—is applied round the base of plants, especially if the growth has not been quite satisfactory. Even if the growth be normal this application of oilcake is much to be recommended as the crop responds strikingly well to this manure. About half a ton per acre will be a suitable dose.

The nursery for raising the seedlings for dry cultivation is sown about the end of June or the first week of July so that the seedlings may be about 40 to 50 days old when they are to be transplanted. The nursery is generally made in the back yards of the houses or in well enclosed corners of the fields close to the village, within easy distance from a well or other water source. The nursery is well prepared by digging to a depth of nine inches, removing weeds and stones and reducing the soil to a fine tilth. Cattle manure and ashes are applied and worked in and the plot laid into flat beds of about three feet square. Chilli seeds are taken from fruits selected and dried from the previous crop which are now split open for the seed. About 1½ lb. of seed will give enough seedlings to transplant an acre. It will be useful to rub the seeds lightly between the hands with a little kerosine oil in order to keep off ants which often carry away a lot of seeds from the seedbed. In any case the seeds should be mixed with some ashes and then strewn thinly in the beds, the soil stirred well with the hand and then lightly pressed down. The beds are given a good soaking irrigation and the watering repeated every day thereafter. It will be well to cover the beds with some straw or dried leaves at this stage both to shade the young sprouts as they come up and also to break the force of the watering which may otherwise wash the seeds to one side or corner. The watering should preferably be by means of a watering can. The seeds sprout in about ten days from sowing. With regular watering the seedlings make vigorous growth. After the plants are well established the watering is done once in two days so as to harden the seedlings somewhat. Further, if they have come up too thick a certain amount of thinning should be done so as to prevent the plants from becoming tall and leggy. The beds should be kept clean and well weeded. Seedlings for transplanting are taken out after giving the beds a good watering, so that they may be pulled out without damaging the roots. Seedlings are to be pulled out to the extent that they can be transplanted in the day and every day as many as may be required. Very often

the soil dries and does not possess sufficient moisture for transplanting without a break; a succeeding rain will have to be awaited for completing the whole area. For the same reason it will be advisable to sow the seed beds in two lots, the second one following the first at an interval of a week or ten days, so that only seedlings of the correct age may be transplanted.

When chillies are grown as an irrigated crop the field is prepared in the same way as already described if grown on a field scale, and if on a small scale then the field is dug to a depth of nine inches. After the field is made ready furrows are made at distances of two feet from each other with small cross bunds about 12 feet from each other for facility of irrigation. Water is let into the furrows and the seedlings are transplanted in the soft mud at distances of one foot from each other and along one margin of the furrow. Irrigation is given every other day until the plants become well established after which it is given at intervals of five days or a week depending upon the retentiveness of the soil and the frequency of the rainfall. The interspaces between the furrows are hoed with bullock hoes once soon after the plants have started making new growth, and later on after a month are also hand weeded. A good dressing of powdered oilcake manure, groundnut cake or 'honge' oilcake is applied now in the furrows at the rate 10 or 15 cwts. per acre, the furrows covered and the rows well earthed up, by splitting the ridges and converting them into furrows. It is also usual in some villages to apply green manure in the form of 'honge' leaves in the furrows before closing them up. Artificial manures can be applied at this manuring; a mixture of 2 cwts. of sulphate of ammonia, 4 cwts. of superphosphate of lime, and one cwt. of sulphate of potash is recommended, half of this being applied at the time of transplanting and half at the earthing up stage. Growth is vigorous from now onwards, the plants branch freely and grow into small bushes. Flowering begins in about one month after transplanting and flowering and branching with more flowering go on apace. In another three weeks or a month the first bulk of green chillies is ready for picking, and of these a small proportion is gathered for sale or domestic use. From about the month of November the first formed chillies become ripe and change in colour to a deep orange and then to red. Commencing from the bottom of the plants the ripening proceeds gradually upwards and the ripe fruits are gathered as they become ready. About the middle of December the picking is in full swing and some seventy per cent of the crop is gathered. Irrigation however prolongs the life of the plants and the plants continue to bear and pickings may go on up to the end of February; the number of pickings may be from six to ten in all. In the case of dry land chillies however the gathering is somewhat earlier and the picking is not spread out over as long a period as in the case of the irrigated crop. As the crop is gathered it is put out to

dry in the sun on good hard dry ground, on the flat roof of the houses or on top of rocky little eminences, etc. If the color is not fully developed, the chillies may be heaped up until they are fully colored up and then spread out to dry. It is sometimes usual to smear the chillies over with a paste of red earth and then put them out to dry, but the general practice is however to dry them without this treatment. It is claimed that this treatment makes the chillies dry quicker and with a smooth surface without any wrinkling. The dry earth is rubbed off when the chillies are quite dry which are further cleaned by shaking them up in a sieve. It is also usual in some cases to trample the chillies lightly as they are drying, so that they may be flattened and rendered more fit for packing in bags for storage and transport. The chillies become dry enough to store or market in about fifteen days of good sun.

Yield.—The yield from dry land chillies is about 250 lb. per acre on the average; a very good crop may however amount to three times this quantity. Yields for irrigated chillies will amount to 1,500 lbs. per acre for an average crop and may go up in the case of very good crops to 2,500 lb. per acre. The proportion of dry to green chillies varies from 25 to 30 per cent.

Hot Weather Crop.—Chillies are grown to a considerable extent as a hot weather crop also. Compared with the areas grown in the monsoon season this is very small and the produce is sold mostly as green chillies. There is generally a good demand for these and the supply is limited owing to the expense of raising the crop; as prices are usually high the crop is considered a highly paying one. For raising a hot weather crop a good irrigation source which will give an unfailing supply throughout the crop season is obviously an essential pre-requisite. The cultivation is generally carried on only under well irrigation. The season for transplanting chillies for the hot weather crop is the month of February, before which a nursery has to be raised in good time and the seedlings got ready. The method of cultivation differs little from the one already described for the monsoon crop of irrigated chillies; irrigation has to be given however more regularly and frequently and this is indeed the most expensive part of the cultivation. The crop is also picked and marketed in the green state and begins to come in from the month of April and continues to the end of May. The yield per acre will amount to about 6,000 lb. of green chillies.

Botany and Varieties.—The chilli plant belongs to the order Solanaceæ and the genus Capsicum. The cultivated varieties of the chilli are classified under the species Annuam. The plants have a strong tap root and many branching lateral roots and rootlets penetrating the ground to a depth of about 18 inches with about the same lateral range. Rootlets and root hairs are abundantly developed and any lumps of manure or fertiliser in the soil may often be found one matted mass of rootlets. The

leaves are lanceolate, somewhat broad across the middle, smooth and alternate. The stem is thin, herbaceous, cylindrical and many branched. Branching is very free and abundant and the branching method is interesting. The flower is terminal and below the flower the stem divides into two branches; each of these branches develops and flowers at the extremity and below each flower the stem again divides into two branches each of which bears a flower in its turn at its extremity and such branching and flowering continue until the plant reaches its full size. The plant is a low bush reaching a height of two to three feet. The flowers are bisexual, with a five-lobed corolla and five yellow stamens, the anthers of which unite and cover the pistil like a hood. The fruit is a berry, short, long or rounded according to variety, with the seeds packed round a central septum.

There are several varieties or sub-species which are under cultivation and which differ from each other in the shape, size and colour of the fruits, and the degree of their pungency. The common field variety grown as a dryland crop in Mysore is the variety Acuminatum; the fruit is thin almost stringlike and pendent, and very long, often about five inches, and has a pointed tip which curls up slightly when the fruit dries. The variety 'longum' has much larger and thicker fruits, the base about ½ to 1 inch wide and the tip about half this size. The variety called 'Guntur' in the local bazaar belongs to this class. The variety 'grossum' is a strikingly large fruit, either short and bell-shaped or long and thick; many of these are given fancy names such as 'bull nose', 'elephant trunk' and so on. They are brilliant red, or a bright orange yellow as they ripen and are invariably very bland and without any pungency. For this reason they are cooked like ordinary vegetables, often being stuffed and baked. The variety 'cerasiform' (or cherry-shaped) has fruits which are small and rounded and are of various colours such as green, red, creamy white, purple or orange yellow; those called the 'Japanese' kinds have their fruits often borne erect pointing upwards and sometimes in clusters. The variety called 'Salem' in the Bangalore bazaar has small rounded fruits and belongs probably to this type; on account of its long peduncle in proportion to its size the kind is not much esteemed. The thin needle like fruit called 'bird pepper' is a large bush and perennial, and is classed under the species "fruitescens, var. minima". It is extraordinarily pungent, and the fruits are only about an inch or two long, and thin as a wire nail; when ripe they are a brilliant red in colour. No other chilli can approach this kind in pungency. In addition to the above are some European kinds, called Hungarian paprikas, which are creamy white in colour, bell-shaped with a broad base and a somewhat tapering end and about two inches in length. These are mildly pungent and are reputed to be very high in the content of vitamin C. All

chillies are fairly high in their vitamin C content, though the paprikas excel other kinds in this respect.

Pests and Diseases.—The most common insect pest on chillies is the thrip pest—*Scirtothrips dorsalis, H.* These infest the plant in large numbers, suck the sap of the leaves and stems, causing a reduction in the size and a malformation in the shape of the leaves, a weakening of the stems and a virtual stoppage of further growth. The leaves eventually drop off and the yield is greatly diminished; if the attack comes on in the early stages of the growth of the crop, there may be no yield at all. Spraying with tobacco decoction about twice at short intervals will materially keep down the pest. Stimulating the growth with oil-cake manure or with sulphate of ammonia will also help the crop to shake off the pest. Keeping down the thrip pest by spraying acts also as a control of what is considered a "Virus" disease of chillies, in which both leaves and fruits become much reduced in size leading to serious reduction of crop. The thrips form an insect vector in spreading the disease. Borers into the stem and into the fruit are also occasional pests but are not of any serious consequence.

The chilli crop is subject to a serious disease, *viz.*, *Vermicularia capsici Syd*,, which causes a kind of die-back. It attacks mainly the upper portions of the plants, spreading gradually from the top downwards and causing the branches to dry up. The disease is favoured by moist weather and by shade and heavy dew on the leaves. Spraying with Bordeaux mixture has been found useful in controlling the disease.

Anthracnose (or *Colletotrichum nigrum E and Halst.*) is another serious disease on the chilli plant. It attacks the young and half-ripe fruits on which the appearance of grey spots and patches of decay form the outward signs of the attack. The fruit becomes dry, and shrivelled and drops off prematurely. Bordeaux mixture is not of any use and control measures consist only in preventing the spread of the disease by removing all attacked plants or branches and burning them.

Chemistry and Uses.—The pungency of the chilli is due to the active principle 'Capsicin' which is contained largely in the skin and dried membranous septa inside rather than in the seeds themselves. Its pungency is so great that the tongue can feel the 'bite' even when it is present to the extent of 1 part in 1,000,000. Its chief function as a condiment is to increase the appetite and to make the rather coarse and insipid grain foods more acceptable to the tongue and therefore to be consumed in much larger quantities than it would be otherwise possible. It is however said to be helpful in digestion with sluggish systems and to possess other medicinal qualities as well. It is nevertheless a condiment to be warned against in spite of these characteristics as it may easily lead to dysentery, inflamed bowels and

so on. The people of the Northern Circars of the Madras Presidency are unique in the quantity of chillies they consume with no apparent detriment to their health; on the other hand, they are a strong and sturdy people, and it is a matter for investigation whether they are so, on account of or in spite of, this partiality for chillies.

III. TURMERIC. (Curcuma longa)

VERNACULAR NAMES FOR TURMERIC:—*Kannada*—ARASHINA; *Tamil*—MANJAL; *Telugu*—PASUPU; *Malayalam*—MANJAL; *Hindustani*—HALDI.

The turmeric furnishes one of the important spices largely in demand in India and other oriental countries and a dye of moderate importance both in India and outside. The plant is cultivated for the sake of its underground swollen stem which is the product which is used as dye and as a spice. The commercial product is obtained not only from the plants which are cultivated but also from plants growing wild. In some of the species the corm possesses considerable fragrance, for which they are specially esteemed.

Distribution.—Turmeric is cultivated throughout India and the cultivation extends into other Asiatic countries like the Indo-Chinese peninsula, parts of China and the East Indies. In the moist shady valleys and hill-sides of peninsular India along both the Eastern and Western Ghats, large areas of wild turmeric are met with and it forms one of the important minor forest products. In the deltaic tracts and far into the interior, both in peninsular India and the north including the Punjab, from sea level upto an altitude as high as 4,000 feet the plant occurs under cultivation; in a wild state it can be seen even on higher altitudes.

Soils—The soils suited for turmeric are sandy loams or clayey loams which are thoroughly well drained. On the latter class of soils where the large admixture of clay interferes with proper drainage the crops are grown on a system of ridges and furrows. The crop requires a highly fertile soil and for this purpose the black fertile somewhat clayey soils such as are found under tank irrigation are also largely put under it, making suitable arrangements for drainage as stated above. The soils are generally of good uniform texture free from stones or gravel or too coarse fractions. The most common soils are however the light red, brown or ashy coloured sandy loams, and loams suitable for heavy irrigation. In the soils where it grows wild the soils are generally of the usual red clayey loam type, well drained on account of their situation on sloping ground and containing large quantities of leaf mould from the accumulation of the fallen leaves from the jungle trees under the shade of which it

flourishes best. The soils are generally to be of the best with no trace of alkalinity or other defects.

Rotation.—Turmeric is grown under conditions where irrigation water is plentiful whether from wells, tanks or channels. It requires good cultivation, and heavy manuring. It occupies the ground for almost a whole year and is therefore the only crop of the year, there being no question of a second crop. It is therefore grown as an intensively grown irrigated garden crop and generally only comparatively small areas are put down by individual growers. A variety of garden crops enters into the rotation if it is grown under well irrigation, such as maize and potatoes, chillies, irrigated ragi, sugarcane and even rice. Where it is grown under tank or channel irrigation, it is followed by rice, and catch crops like the pulses, green gram, black gram or cowpea, the turmeric being grown after two or three crops of rice; sugar cane and plantains also enter into the rotation, in these tracts of flow irrigation, in which case turmeric gets a chance once in five or six years. Where turmeric is a favourite crop, the rice and catch crops for a couple of seasons followed by turmeric is a common rotation, provided the water supply is abundant. In tracts of heavy rainfall as on the west coast districts turmeric is grown solely with the help of the rainfall, no artificial irrigation being provided.

Cultivation.—It is usual to grow a number of subsidiary or mixed crops along with the turmeric in the same field, generally along the margins and near the irrigation channels. At least one shade crop is included as the turmeric is a shade-loving plant. For this purpose castor is the one usually selected, but garden 'togare', and 'agathi' or 'Sesbania grandiflora' also form a sprinkling here and there. The mixed crops grown are ginger, the elephant yam, colocasia, brinjals, radish and other vegetables. Turmeric is to a considerable extent grown by itself also, but one or more shade crops are always provided, these being garden 'togare' and castor.

The season for planting is from the second half or end of April up to the beginning of July. The field has to be thoroughly prepared either by digging or by several ploughings—about six are usually given—in good time before the planting. Clods are broken, weeds, stubbles, roots, stone and gravel are removed by the plough and cultivator, and cattle manure is carted at the rate of some forty cartloads per acre and ploughed in. Considerable tank silt is also carted, and sometimes sand if the soil is inclined to be clayey. Sheep are also penned. The crop is in these ways heavily manured. After the manure, sand, tank silt, etc., are ploughed in, the field is laid out into beds for irrigation. The irrigation beds are made about 12 feet wide and from 12 to 18 feet in length; an irrigation channel divides every two of these beds, and the individual beds are themselves divided by a low dividing bund for convenience of irrigation. The beds

are thus really six feet wide and 12 to 18 feet in length. The whole field is also surrounded by a drainage trench about one foot wide and 18 inches or two feet deep. The turmeric corms are now planted in furrows one foot apart and 9 inches from each other in the furrows and pressed in flat about two inches into the ground. Turmeric is sometimes planted also on the flat in these beds at distances of six inches each way. At the same time in each of the corners of the beds a castor seed or 'togare' seed is sown. They are also sown along the outer bunds of the field where they grow into a hedge. Along the low bunds separating the beds 'colocasia' is planted a foot apart and along the water channels the 'elephant yam' is planted at distances of four feet from each other.

Quick growing vegetables like radishes and greens are also scattered in the beds in between the turmeric. The further operations comprise regular irrigations and ho eing and weeding with hand ho es. The turmeric crop is well above the ground in about a month and with good irrigation makes rapid growth and covers the ground. The minor vegetable crops are by this time all removed. In furrow planted turmeric the rows are now earthed up by splitting the ridges between the furrows. In about the month of November, the turmeric ceases to send up any further leaves. The corms now begin to thicken and their colour becomes deep and uniform. About the month of February the leaves begin to yellow, and dry one by one which is an indication of the ripeness of the corms and of the time for digging them. The digging commences in March and goes on until the end of April. On a small scale corms are dug for sale even before this stage; contrarily the crop can be kept in the ground longer without being harvested and dug later on when prices may be higher.

In tracts of heavy rainfall as in the Malnads or in the districts of the West Coast, the turmeric is grown in narrow elevated beds divided by drainage trenches. These trenches are 18 inches wide, 18 inches apart and about 9 inches in depth. The beds are about 18 inches above the level of the ground. Turmeric is planted on the beds in a single row along the centre at distances of nine inches from each other, or in a double row at six inches intervals, into holes in which some cattle manure has been applied and well mixed with the soil. The rows are now covered over with a thick mulch of leaves. After the turmeric has sprouted and grown above the leaf mulch the latter is removed and along with more leaves is spread all round the plants on the beds, thereby serving to break the force of the rains. The corms ripen and become ready for digging in about nine months after planting.

Seed Turmeric.—Seed turmeric is saved from the harvested crop for planting in the season following. For planting purposes only the 'fingers' are used and not the 'rounds'. These are

kept thinly spread under a light cover of turmeric leaves and are taken out for planting as required during the following two months. Seed corms should be quite ripe and have a sound bud at the growing end. Seed corms are usually put in without any treatment but occasionally they are dipped in a thin paste of cowdung and water and then planted. The quantity of seed turmeric required for an acre varies according to the proportion of mixed crops proposed to be grown along with it and the distances of planting. Raised as a pure crop, about 1,500 lbs., will be required per acre but this may go down to about half the quantity at the lowest and to about 1,000 lbs., in average mixtures.

Curing the Turmeric.—In digging the turmeric crop, care should be taken to see that the corms are not cut or bruised and the whole clump is lifted out with the dry plant. After the clumps are dug, the leafy tops are cut off, the roots removed, and all adhering earth shaken or rubbed off. The 'fingers' are separated from the 'rounds'. A small quantity of turmeric 'fingers' is sold in the raw state as it is fancied in most South Indian households; the commercial product is however the dried turmeric. The harvested crop has therefore to be converted into 'dried turmeric' before it can be marketed. Turmeric can be dried only after it is slightly boiled and the cells killed. Most of the turmeric is boiled whole; but in the case of the 'rounds' and to some extent in the case of the 'fingers' also it is usual to cut them into two halves along the length and then boil them. The 'fingers' when they are rather long are also broken into two shorter lengths. Before it is taken up for boiling the crop generally undergoes a slight amount of sweating in heaps covered with the turmeric leaves. The turmeric either whole or split or consisting of both whole ones and split ones is charged into earthenware pots or the large iron pans used for jaggery boiling, water is poured in until the water stands about two inches above the level of the turmeric; it is then covered over with the dried turmeric leaves and the boiling started. Sometimes the water used has some cowdung stirred into it. As the boiling progresses the turmeric is tested now and then to see if it is ready for taking down. If the turmeric becomes sufficiently soft as to yield to slight pressure between the fingers and the thumb, somewhat like the boiled potatoes of the waxy types, then it is considered ready for removing from the fire. The corms are taken out, drained and spread out in the sun to dry. They require seven or eight days of good sunshine to become dry enough to store and market. The outturn of the dry turmeric varies somewhat with the quality and ripeness of the raw turmeric from 17 to 25 per cent.

After the turmeric is quite dry, it is cleaned to remove any bits of roots and then rubbed well between the hands. Sometimes a little turmeric powder is mixed with the turmeric when

it is being rubbed. A mechanical appliance to simplify this work is a revolving drum like an ordinary barrel type butter churn into which the turmeric is put together with the turmeric powder as required and rotated to give it the necessary colour and the polish. The product is then sorted out into 'rounds,' 'splits' and 'fingers,' and also graded into large and small according to market requirements.

Yield.—The yield of turmeric when it is planted pure and cultivated with liberal manuring and irrigation is usually reckoned as about 3,500 lbs. of cured turmeric per acre. Yields up to even double this figure, *viz.*, 7,000 lbs., of cured turmeric per acre are also reported but on the average a crop of only some 2,500 to 3,000 lbs., per acre can be relied upon.

Botany and Varieties.—The turmeric plant belongs to the order Scitamineæ and the family Zinziberaceæ, which embraces two other important crops, *viz.*, ginger and cardamoms. The order itself includes the familiar plantain and the ornamental plant canna. The turmeric is propagated from the swollen underground stems or corms. The corms are divided along their length by means of circular slightly scaly rings which form the nodes from which spring leaf buds. When planted in the ground the plant sends up a shoot from this eye bud at the growing end which shows itself, well above the ground and opens out its leaves in about a fortnight to a month from planting. The leaves comprise a broadly lanceolate blade bright green in colour and surmounting a petiole which is thin and narrow near the leaf but broadens out at the base and envelops the succeeding shoot about half way round like a sheath. The leaves are as long in length as the blades, are smooth on both sides, the margins are entire and the tip is narrowed and pointed. They are small in size at first but as the plant grows increase both in length and breadth and in well grown specimens are about two feet long and about six or eight inches broad across their middle. The stem which is really composed of the expanded lower portion of the petioles thickens, has further a flattish appearance, the earliest formed petioles being pushed open somewhat as the stem thickens. The plants attain a height of about four feet when fully grown. The root stock develops at the base of the plant which swells into a rounded corm from which leaves are sent up above the ground and roots and new corms develop underground. The 'rounds' of commerce are formed by these root stocks from which spring the primary corms, or 'fingers'; secondary corms grow from the primaries which thus become many branched and about four to six inches long; the secondary corms are however much shorter. The finger corms are ¾ to one inch in diameter. The roots are smooth and fleshy for part of their length and develop rootlets lower down. The roots generally travel straight downwards and penetrate to a depth of about nine inches to a foot. The turmeric plant occasionally

sends up flowers here and there but these are very few indeed. The flowers are dense spikes crowded with a coma of enlarged bracts; the lower bracts are ovate and membranous and enclose several bracteolate fugitive flowers; the calyx is short, corolla funnel shaped, lateral segments oblong, upper longer, ovate and concave. There is one perfect stamen and the lateral staminoids are petaloid. The ovary is three-celled, style filiform and stigma two lipped. The seed capsule is three valved and globose.

Although there are no sharply distinguished varieties in the cultivated turmeric, still the turmeric of certain localities possesses a reputation for special characteristics, such as the size of the corms and the depth and fastness of the dye. In South India the 'Madras Manjal' is famous for its colour. The cut surface of the cured turmeric is dark brown in colour, smooth and almost oily to the touch; it dyes a deep yellow which is comparatively more persistent and difficult to wash off than others. Both 'rounds' and 'fingers' of this kind are esteemed in this way. The round corms from Malabar and Cochin are reputed for their size, being considered the largest in the market. A variety grown in Poona is considered of a deep tinge and so is the Patna variety in Bengal esteemed for the depth of the tint. All turmeric yielding a deep dye cures much harder on drying than those used mostly for condiments. The cultivated turmeric 'Curcuma longa' is often confused with the wild turmeric—Curcuma aromatica—distinguished as 'Kasturi' turmeric in South India. The corms of this turmeric are much larger, and many are rounded. The flesh too is only light yellow and some times even whitish. The cured turmeric has a sweet fragrance and is used largely for bathing powders, perfumed bathing oils and similar purposes. It is also credited with specially medicinal properties generally similar to the ordinary turmeric.

In some parts of Mysore three types of turmeric are distinguished. One is called 'Mundaga' and in this the clump of corms is large, thick set and has many fingers. A second variety is called 'Balaga' and in this the corms are not so thick or so many in number. The third is called 'Yelachaga' and in this the corms are small and few, and the roots, numerous. Crops are generally mixtures, but when seed corms are selected, the third kind is as far as possible picked out and removed.

Many of the 'curcuma' species are very similar in appearance, and are likely to be mistaken one for the other. Among these the most important one other than the 'aromatica' is the East Indian arrowroot C. angustifolia and the so called mango-ginger C. amada, the odour of which when tender resembles that of green mangoes. The corms of this variety are much thinner than in other varieties and the flesh is whitish and not yellow.

Pests and Diseases.—The turmeric must be considered singularly free from pests and diseases. A few however are known which are by no means serious.

The leaf folds are eaten by the green coloured larvae of a butterfly—*Udaspes foleus Cr.*,—and some little damage is caused thereby. The pest can be controlled by hand-picking the larvae in the early stages. Of equally minor importance are other insect pests like thrips and certain scale insects occasionally found on turmeric.

Among insect pests, the only one of importance is the shoot boring caterpillar—*Dichocrosis punctiferalis, G.*—the castor pod borer. The caterpillar bores into and cuts the central shoot which dries up as a result. Removal of the shoots as soon as they are seen to show signs of wilting and destroying the larvae contained inside is the only practicable control measure.

The only disease noticed on turmeric is the leaf spot disease *Taphrina maculans, Buttl.*—These are brownish yellow spots covering the leaf blades, mostly on the upper surface, which increase in number and also coalesce into larger spots. They weaken the plants and lead to a reduction in the yield, though they cause no destruction by the drying up of the plants or of many leaves. Spraying the leaves with Bordeaux mixture will arrest the spread of the disease.

Chemistry and Uses.—The turmeric is an important spice or condiment in Indian cooking and is largely in demand for this purpose. It is a symbol of auspiciousness among the Hindus and on weddings and all auspicious occasions is an article of presentation among the womenfolk. As a medicinal article it is used for external application in pains and for relieving catarrh and eye diseases. Taken internally it is said to act as a stimulant and aromatic tonic, and is in many respects a favourite household remedy. The turmeric both raw and dry is considered a remedy against skin diseases and itches. It is also one of the principal cosmetics used by Indian women though in recent years the turmeric is all but banished and its place has been taken by the face powders and creams used by European women. In addition to the yellow dye the turmeric also contains a volatile oil—turmerol—which has the somewhat fragrant odour of the turmeric.

As a dye the turmeric is not fast; it can however be used without a mordant. It is used for dyeing cotton, wool and silk. The yellow colour is changed to red by alkalies and into brown by boric acid. When turmeric is used to adulterate other milled products the above property is made use of for detecting the adulteration.

IV. CARDAMOMS (Elettaria cardamomum).

VERNACULAR NAMES FOR CARDAMOMS:—*Kannada*—YELAKKI; *Tamil*—YELAM; *Telugu*—YELAKAYALU; *Malayalam*—YELAM; *Hindustani*—ELACHI.

The cardamoms of commerce are the fruits and seeds of the cardamom plant, Elattaria cardamomum, and they comprise one

of the most important and costly spices of the world. The product has been known from the most ancient times although its cultivation is confined to a very limited tract of the tropical world. It is not only a cultivated product but is also derived to a considerable extent from wild growth in regions where it forms part of the special natural vegetation. It is almost entirely a South Indian product, though its cultivation extends to Ceylon, the Eastern Archipelago and Java to a comparatively small extent. Though the true cardamom of commerce has only a limited sphere of cultivation there are a number of allied species which are cultivated in other parts of the world also, such as in Indo-China, North Eastern India, East Africa and West Africa. Reference is separately made to these products under 'Botany and Varieties.'

Distribution, Climate.—The true cardamom is confined to a special range of climatic and other conditions for its successful cultivation. A very heavy and generally well distributed rainfall exceeding 60 inches and going up to even 150 inches, an altitude of 2,500 to 5,000 feet with a warm humid atmosphere with temperatures ranging from between 60° and 95° and a zone well situated within the tropics generally composed of evergreen forests are necessary for the cultivation of the crop. Moist situations such as the margins of shallow ravines with a deep natural mulch of fallen and decaying leaves form very favourable additional factors. The western taluks of the Mysore State lying on the spurs of or adjoining the Western Ghauts, the Coorg country, and the whole ghaut country lying all along the Western Ghauts down to Travancore on both the eastern and western ranges, and reaching northwards up to the hill tracts of North Kanara and Konkan are the areas where the cardamoms are cultivated and can be seen growing and flourishing even in the wild state. The areca gardens of Kanara, and Shimoga, the coffee tracts of Hassan and Kadur, Coorg, the Anamalais, the Cardamom Hills of Travancore and Madura, comprise specifically the large cardamom growing tracts of south India. Though these tracts form the most important areas of cultivation the cardamom is capable of being grown at much lower elevations also as in Ceylon and Malaya, the rainfall however being equally heavy. An eastern aspect especially south-east is considered best.

Forms of Cultivation.—Cardamomsa re grown generally as a pure plantation crop and on a large scale, much as coffee or rubber or tea. In many coffee estates small areas are occupied by cardamoms especially in the moist situations and alongside shallow ravines. In arecanut gardens in the Mysore Malnads and in the coastal districts of Southern Bombay, cardamoms are grown by garden owners as a subsidiary crop almost invariably, a mode of cultivation which is quite important considering the large number of growers cultivating it though in respect of

acreage it is almost negligible compared to the plantation cardamoms. A third kind of cultivation is a peculiar one; in this the natural growth of cardamoms as an undergrowth in the favourable forest zones is aided in varying degrees by actual cultivation; the latter ranges from conditions where the cardamom is wholly a forest product and practically grows under wild conditions up to conditions where it approximates closely to systematic cultivation except for the fact that it is a temporary and shifting one. Areas are abandoned and allowed to revert to jungle after a few years of bearing and then a new area is taken up for similar cultivation.

Soils.—Cardamoms are grown on the red lateritic loams characteristic of the tracts named above. Only good soils without any stones, gravel or grit and possessing good depth are selected. Jungle soils with a large admixture of leaf and leaf-mould and in varying stages of slow decay giving the soil not only its fertility but also a springy tread are ideal. The felling down of large forest trees resorted to in the clearing of new areas is said to produce a kind of low tremour in such soils which is believed to be favourable for causing many new seedlings to sprout from self-sown seeds.

On the margins of ravines often boulder-strewn, cardamoms can attain very good growth in the pockets of soils among the boulders even if the soil should be lacking in depth. The soils of these tracts are generally acidic, with a p H. value of about 4·5 to 5·5. Though coolness and abundant moisture are essential conditions for the growth of cardamoms and though many low situations are put under the crop, drainage is essential. In the low situations and the ravine margins there is generally moving water not far from the root zones of the crop, so that neither stagnation of water nor swampy conditions prevail. On level land and even on sloping land where on account of the heavy rainfall the water may not drain off sufficiently quickly, the stagnation of water about the roots is prevented by means of regular drains or the drainlike excavations called 'renovation pits' usually dug in many estates.

The Clearing of Forest and Shade for Cardamom.—The cultivation of cardamoms on a plantation scale is taken up on the hills and hill slopes of the tracts described already which are all fairly good tree-clad forests. The forests have to be cleared suitably not only of undergrowth but also of the forest trees before cardamoms can be planted. Cardamoms need a heavier shade than coffee and can do with a loftier canopy. Trees which will answer this need have therefore to be left and the rest cleared. It is also noticed that considerable intermingling of the roots of cardamoms occurs with the roots of the jungle trees in the plantations without apparent detriment to the cardamoms so that a heavier stand of trees is permissible consistent with actual planting space for the crop. In getting rid of the

cleared material, the need for a heavy mulch and of organic matter in these soils for the cardamom crop has to be borne in mind and the extent of burning will have to be restricted to suit the conservation.

Where the land selected does not possess this advantage and the tree growth is either sparse or not high enough then suitable shade trees will have to be planted, both quick-growing nurse shade such as Erythrinas for temporary shade in the earlier years and of trees with a tall and spreading habit which will give a good and high enough canopy for permanent shade. Further information in regard to shade on plantations is given under 'Coffee.'

Propagation Methods.—The propagation of cardamoms is by two methods, *viz.*, (1) by the sowing of seeds and raising seedlings and transplanting them in their permanent places in the garden or the plantation and (2) by dividing up the group of rhizomes in a clump of large growing plants and planting out the individual rhizomes as separate plants. The first method may be said to be the more general one and also the more convenient one in practice, as it is only by that method that the large number of plants required even for small areas of a few acres can be secured. It has of course the drawback that the progeny is largely of a mixed character and it is not possible to obtain plants all of a desired type or variety, inasmuch as the cardamom is a cross-fertilised plant in nature. The propagation from rhizomes is free from this defect, but in practice it will be difficult or impossible to obtain a sufficiently large number of rhizomes for planting out. It also means the pulling out in part or full, large bearing clumps which may be neither advisable nor practicable. It has however the great advantage of ensuring type or variety, and in building up areas of a really high yielding disease-resistant or other types possessing any special desired quality it is the only method possible and if such areas are not large is well worth resorting to. Nevertheless even in ordinary practice, the propagation from rhizomes is not uncommon, rhizomes being available from areas being thinned out or from estates where certain areas are made use of specially for the purpose of supplying rhizomes for sale or multiplication in the estate itself. On the other hand, the prevalence in recent years of a 'mosaic' disease in cardamoms introduces the risk of disease in rhizome-propagated plants.

Nursery.—Cardamom nurseries in Mysore are made in low flat moist situations in valleys where water is abundant and generally form flowing springs even in the hot weather; in the rain, these flow like streams and the nurseries are surrounded and sometimes all but submerged. These are areas which are sometimes laid out into paddy flats and where the natural vegetation comprises considerable screw pine. On these situations which are known locally as 'hanals' nursery beds are made

which are long ridges about 9″ to 1′ high about 2′ broad, and divided from each other by a trench about 9″ deep. The trenches run both along the length and across so that the ridges are a series of long narrow rectangles about two to three feet wide and some 12 to 15 feet long, and divided from each other by the trenches. The ridges are made up of good soil from the surface of the jungle with considerable admixture of leaf-mould to make it friable and to prevent caking. It is also carefully sifted to remove large lumps and stones. The area is securely fenced. Provision is also made to erect a temporary bamboo framework over the nursery about five feet high, over which dry ferns and certain leaves (of a kind which do not crumble or drop off when dry) can be slung for affording shade.

The seeds for sowing are obtained from ripe well-formed cardamom fruits, which are fresh, sound and free from any borer attack. As soon as the fruits are picked,they are opened out and the seeds removed. The seeds have still considerable mucilage adhering to them and in order to separate them and facilitate even sowing they are rubbed with ashes and spread thinly to dry in the shade. They are ready for sowing immediately they are dry enough. About a pound of good seeds will furnish enough plants for one acre of plantation. The seeds are sown by scattering them thinly over the nursery bed and giving a good stirring to cover the seeds. The ground is gently pressed or tamped with the hand and then covered over with straw, dry leaves of plantain and other mulch. The sowing is done usually in the months of September and October, when the picking of the cardamoms is at its peak. In five or six weeks the seeds begin to sprout and in about 45 days show distinctly above ground, are about 6″ in four months and in about a year are 18″ in height. The germination is very irregular and the seeds do not sprout at or about the same time, but keep coming up at different intervals; even after one year from sowing, sprouts can be seen to emerge—a fact which is perhaps due to differences in the viability of the seed and to the varying depths at which they lodge when sown. Seed is sown usually very thick and the plants in the nursery are very crowded. If a thin stand is secured by sowing less seed or by thinning out after a sufficient number has sprouted, then the seedlings attain even three feet in a year. The thick sowing however has the advantage that it ensures a sufficiently large number of seedlings of moderate growth for planting out and somewhat counterbalances the trouble of irregular and belated sprouting.

In regard to shading the nursery much virtue is claimed for the leaves and branches of 'Phyllanthus emblica' and it is usual in Mysore to use these for this purpose both in the nurseries and for the newly transplanted seedlings, the branches being stuck in the ground on the bed close enough to afford them shade. As a matter of fact however the leaves of the Phyllanthus

soon drop off completely or they dry and leave the branches quite bare. The beneficial effect is probably due to the astringents, gums or other active principles in the leaves and branches as is sometimes suggested, and as the leaves are credited with the power of keeping off vermin and insect enemies. In the areca gardens it is the invariable practice to apply these leaves to the cardamom plants as manure and perhaps for the sake of the above advantage as well.

From these nursery beds the seedlings when they are four to five months old are transplanted to other similar beds where they are put out thinly and at regular distances of about ten inches between plant and plant. These beds are looked after in regard to shading, irrigation and drainage in the same way as the first nurseries. A small dose of quick acting manure which should be lightly hoed in, is recommended for the nursery and will be found a great advantage. It may also be necessary to spray the nursery with Bordeaux mixture as a preventive against various fungus diseases. The manure mixture may consist of a small dose like one cwt. of sulphate of ammonia, and 1½ cwt. of superphosphate per acre.

Transplanting.—The pits for planting the seedlings in their permanent places in the garden or plantation are made at distances of six feet by six feet or five feet by five feet, about 18 inches square and about one foot in depth. Like most other plants cardamoms make remarkable growth where the soil is composed of made up earth in deep excavations. In one such situation cardamom plants were come across in which clumps were more than four feet in diameter and the stems exceeded fifty in number. It may be therefore advisable wherever possible to be liberal in regard to the size of the pits. Top soil is returned to the pits which are filled with jungle soil with a large admixture of leaf-mould. The planting time should be soon after the first rains of the year have fallen and considerably ahead of the outbreak of the monsoon, that is to say, in the months of April to June. Alternatively and somewhat more generally the months following the heavy monsoon when the latter is just tailing off and not quite ended, *viz.*, September-October are selected. Planting is done in the moist soil and just deep enough to cover the rhizome a couple of inches above the crown, the earth is well pressed about the base of the plant and a light bamboo or other stake is stuck somewhat slantingly against the direction of the wind and tied up lightly to the stem of the seedling, in order to prevent it from being broken or blown down by the wind. These stakes should be removed after the plants have established themselves well and the monsoon is over, as they will attract white-ants if left in.

The cultivation in the hill forests is principally one of aiding the natural growth of cardamoms by a certain amount of clearing, weeding and so on. For this purpose the hill properties are

visited by work people in the month of June. The various items of work to be attended to are (1) the felling of a tree here and there, to open up more ground and to induce the coming up of new plants, such plants spring up both on account of the greater amount of light let in and on account of the disturbance and concussion to the soil caused by the falling trees, (2) to put in supplies in blank spaces which will take the place of older plants eventually, (3) to clear weed growth, (4) to clean up around the base of the clumps and to free the flowering spikes clear of the leaf mould and undergrowth.

In areca gardens the cardamom plants are put in close to the margin of the drainage trenches between the areca trees. Though they appear very crowded the plants receive greater attention by way of manuring, weeding and watering ; the fruits are better developed and fetch a higher price in the Mangalore market under the name of Nagar and Chikmagalur qualities. The planting is made generally in the months of August and September. Though the planting of seedlings is the common practice, rhizomes are put in, which have the advantage of coming into bearing about a year in advance of seedling plants, in addition to the other advantages of vegetative propagation. The number of cardamom clumps in an areca garden is very indefinite, depending upon the number of areca trees with which they may vary inversely ; further the gardens are seldom fully planted ; between 400 and 500 plants may be considered an average number per acre of garden.

The yearly cultivation routine consists of weeding in the estate and digging, cutting out of old and drying stems, lopping of shade trees, manuring and the planting of supplies. Cardamoms planted in areca gardens receive the benefit of the elaborate cultivation given to the areca ; the leaves of the Phyllanthus emblica are specially applied to the cardamom plants in addition to ordinary cattle manure. Weeding and digging operations go on from about the month of September onwards. Well-rotted cattle manure and sheep manure are greatly esteemed and with heavy manuring of this kind, very high yields are reported. Fish manure is also sometimes applied. For larger estates some kind of concentrated fertilisers are indispensable, and the following mixture is recommended, *viz.*, 5 cwts., per acre of a mixture made up of 3 cwts. of castor oil cake, 1 cwt. of steamed bone-meal and 1 cwt. of potassium chloride. Cattle manure should not be omitted but in view of the difficulty of obtaining sufficient quantities it can be economised by using manure once in three or four years, by dividing the estate suitably and manuring the sections in rotation.

Cardamom plants begin to bear in the third year after planting, which may be the fourth or even the fifth year after the sowing. The inflorescences spring from the base of the stems of the previous year's growth. They are thin long and much

branched, and grow erect or lie flat on the ground according to the variety. The shoots bearing the inflorescence begin to appear from the month of January onwards, long before they unfold and allow the latter to grow. The flowers are borne in clusters of two or three on the branchlets. Flowers begin to open from the month of April-May onwards and keep on appearing till almost July-August; in fact it may be possible to see a few flowers throughout the year. The peak period of flowering is however May and June. The flowers are freely visited by bees and are therefore cross pollinated in nature. Stigmas remain receptive for 48 hours. As the flowers continue to appear at intervals during a long period the fruits likewise ripen irregularly at intervals necessitating several pickings. From the opening of the flower to the ripening of the fruit is nearly three and a half to four months, and fly picking begins about the end of August and the main picking continues from September onwards until January. Stray pickings may continue up to March, the late pickings being more common farther south in the peninsula. In fact at one and the same time shoots enclosing the young inflorescences, inflorescence buds, spikes with open flowers and those ripening fruits can be seen in many clumps.

The number of flowering spikes, their length and the number of fruits therein in any clump will depend largely upon the variety, age of the clump and the soil, manure and attention it has received. Clumps which are almost seven years old may be said to be in the prime of bearing, containing on an average some twenty stems and about twelve inflorescences. As already stated on well grown specimens as many as 55 stems and 75 infloresences have been counted.

The picking of the fruit has to be done carefully. Each inflorescence has to be gone over and in each only the fruits in the correct stage of ripeness have to be picked. If they are left to ripen further they give fruits which will split in the drying floors. If picked underripe, the fruits shrink on drying and have a shrivelled appearance with small thin seeds. The fruits have to be picked with the peduncle and not merely stripped or plucked carelessly. Every week or ten days the clumps will have to be visited and the fruits gathered as they are ready.

After the cardamom fruits are picked they have to be dried. Both sun-drying and drying by artificial heat are adopted. In the earlier part of the picking season the rains still continue and sun-drying is not possilbe or at any rate cannot be depended upon. Artificial devices are used and these vary from crude local devices like a mud platform over a wood fire up to large drying houses heated by hot air in flue pipes provided with proper chimneys, ventilation and so on. The small domestic type may consist of a hollow platform about two feet wide and six or eight feet long, running along one side of a room, the hollow space underneath running from one wall to the other

opening at both ends outside. Through one end wood fire is lighted and as it burns the hot flames and smoke pass through the hollow and outside, heating the platform. The latter is a smoothly plastered floor and on it the green cardamoms are spread thinly and dried, the fruits being lightly stirred occasionally. In larger domestic driers, the platform runs along two or three sides of the room and firing may be through three or more holes in the walls communicating with the flue-like hollows. In other types similar low and long platforms up to 20 feet long may be erected in sheds open on all sides, and fired from three or four vents along the length. The better class of driers, consist of a tall room about 10′ by 12′ which is heated by means of a large iron flue pipe which runs from one end to the other along the middle of the room; one end of the flue pipe is connected with a regular iron furnace, properly furnished with grating, doors, etc., kept outside the room, and the other end connected with a chimney pipe leading the smoke up through the roof into the air. A series of small holes in the walls serve to lead out the steam from the drying cardamoms. All along the walls are racks to hold the rectangular trays on which the cardamoms are spread out to dry. Better arrangements in up-to-date large driers are made for ventilation and the sweeping out of the vapour by means of fans. In these the flue pipes are made to run along metal—covered conduits beneath the floor. Lack of proper ventilation to carry off the vapour is the most frequent defect in all the small types of chamber driers, and the cardamoms sometimes become disfigured by vapour condensing and dropping on them. In bad cases the drying almost amounts to a cooking. The cruder driers constructed under large open sheds are free from this drawback.

Cardamoms are dried spread thinly in the driers and stirred frequently, the drying being finished in practically twelve hours. By this method the dried cardamoms retain their green colour which is said to be the colour much fancied in recent years in the European and American markets. To obtain a somewhat brownish tint the cardamoms are spread thickly and stirred only occasionally, and when nearly dry are removed and bulked in bags or baskets and the drying is completed at a second stage.

Drying in the sun generally takes three or four days, which produces a certain amount of bleaching, especially so with exposure to the dews of the night. The bleaching can be carried a little further by extending the period of sun-drying, by wetting the fruits slightly and by putting out to dry in the sun alternately several times for two days, and then drying the fruits in the sun without further watering, a process which has its practical parallel in the washing of clothes by the Indian washerman.

In order to obtain the so-called white or bleached cardamoms which is a distinct trade quality and is greatly in demand,

cardamoms are specially subjected to a bleaching process. The Indian demand is met by a peculiar bleaching process which is confined to Haveri in Southern Bombay—a great trade centre for cardamoms. The bleaching process is in the hands of a particular set of people and the bleaching action is said to be largely due, among other things, to the water of certain wells which is used for this purpose. The process consists in washing the dried cardamoms in water containing a mash of soapnut (both 'Sapindus saponaria' and 'Acacia concinna') and also ordinary soap, draining and washing again, draining and then spreading out to dry indoors, with occasional sprinkling with the well water, and then drying in the sun the following day. Bleaching on the estates themselves is also done by means of sulphuring. This consists in exposing the dried cardamoms to the action of sulphur di-oxide produced by burning ordinary sulphur. The cardamoms are spread on bamboo trays placed one over the other in special sulphuring boxes, at the bottom of which well below the lowest tray the sulphur is burned in little tins or saucers. Instead of the box, the small drying chambers are also used. Before sale the produce is further prepared by trimming the ends of the cardamoms, garbling and sorting. Fruits which were not quite ripe when they were picked shrink a great deal on drying and the seeds too are pale or brownish in colour and not black. A number of fruits split on drying partially exposing the seeds, if not scattering them altogether. This is usually caused by over-drying ripe fruits, or occurs in the case of fruits cut too close to the body of the fruit. Other fruits are very small in size. These are all faults and such fruits are removed in the garbling. Round fruits are sorted out and separated from longish fruits, and in both classes distinct colour grades are sorted such as dark green, light green, deep golden and light golden. Markets in India have distinct preferences; thus, Bombay and the West Coast are said to fancy round fruits, Delhi white round fruits, Calcutta and Hyderabad a longish fruit of the bright white kind.

Yield.—The yield of dry cardamoms per acre from estates of good bearing age is generally reported to be about 250 lbs. Between 1 and 1½ cwts., an acre is about the minimum expected, anything below this yield being very low and due to bad season, disease or neglect. On small gardens heavily manured with cattle manure and with good facilities for irrigation very high yields up to 700 lbs. an acre are said to have been attained, which shows the possibilities. Large well-grown individual clumps are known to yield about two to three lbs. of dried cardamoms per clump.

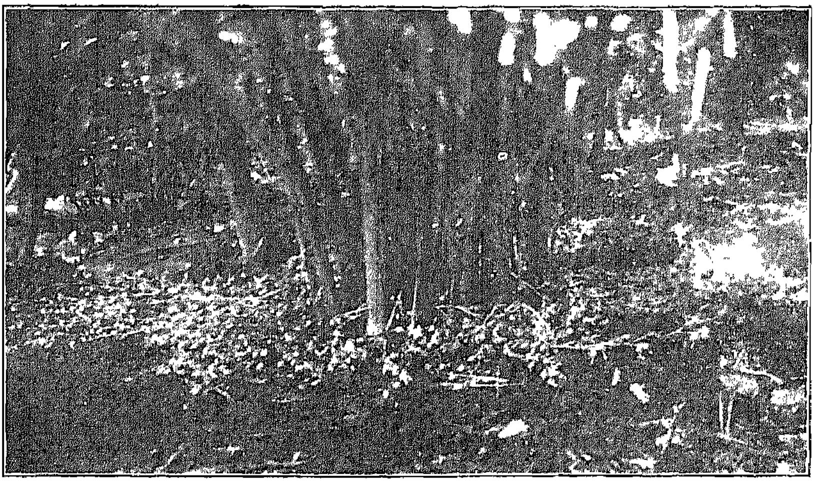
The cost of bringing an acre of jungle land into cultivation under cardamoms, until it comes to bearing, that is, for three years will obviously vary a good deal; one estimate for Mysore conditions puts the amount down as Rs. 260 per acre excluding

the cost of land. The annual expenditure on it thereafter will amount to Rs. 60 an acre including cost of manuring. The price of cardamoms has varied much in recent years; it has gone up to Rs 4 a pound and also dropped down to almost Re. 1 per pound. Taking it at an average rate of Rs. 1-4-0 per pound and an ordinary yield of 1 cwt. an acre, a net income of about Rs. 80 per acre may be expected. A Ceylon estimate for a 25 acre cardamom estate brings out the profit per year per acre to about Rs. 194, the yield being taken at nearly two cwts. an acre and the price at Rs. 2 per pound. An estimate for estates in the cardamom hills puts down the net income at over Rs. 350 per acre.

Botany and Varieties.—The cardamom plant belongs to the natural order Scitamineae and the family Zinziber aceae. They are perennial plants springing from under-ground rhizomes in clumps of a dozen or more with rounded, upright or slightly slanting stems about 1½ inches in diameter, which are formed by the long sheathlike leaf stalks which lie one on the other and form the so-called 'stems'. These individual leaf blades which have a long petiole, and are lanceolate in shape are from 1 to 3 feet in length and from 3 to 6 inches across their largest width. The leaves are dark green in colour and either glabrous or pubescent with a soft velvety undersurface. The clumps generally attain a height of six to twelve feet. The flowering stalks spring from the rhizomes and are generally recumbent and attain a length of anything from two to four feet; in some varieties they are erect or semi-erect but even these bend over and become practically recumbent with the weight of the fruits as they swell and ripen. The flowers are bisexual and irregular; the bracts 2 to 3 flowered, calyx striate, cylindrical and persistent, corolla tube shortly exerted and lateral staminoids of minute teeth, lip obovate cuneate and the capsule subglobose and rounded or three cornered and varying in size in the different varieties. The seed in the ripe capsule is black in colour and embedded or covered over with a thin white mucilaginous coat. The seeds have a hard seed coat and number about 15 to 20 per capsule.

Three varieties of cardamoms are generally recognised, *viz.*, the Malabar, Mysore and Ceylon. A certain amount of confusion prevails in respect of the characteristics, among growers in different tracts and local names like Manjarabad, Malai (or hill), Annamalais, etc., by which the plants are known add to the confusion. Usually a mixture of the different varieties is to be seen, though as far as South India is concerned the so-called Mysore and Malabar varieties may be said to predominate. The characteristics on which there is more or less general agreement are given below.

Malabar.—Elettaria cardamomum. The leaves may be smooth or hairy on the underside. The spikes are about two to three feet long and are recumbent in habit, lying flat on the



CARDAMOMS

I. The trailing variety.

II. The Erect variety. [Mys. Agri Dept.

ground. Flowers are in clusters of two or three. The fruits are globose, ovoid, three sided and lightly ribbed; their characteristic is however the globose rounded fruits. There is much variation in size and shape, leading to considerable sorting in the commercial grades The fruits are smaller than 'Mysore", are yellowish when ripe and are found to be less susceptible to the attacks of thrips, but is more susceptible to the disease called 'katte' probably mosaic (?). The variety known as Manjarabad is identified as 'Malabar'.

Mysore.—This is a very robust variety; the stems grow up to ten feet with large coarse leaves, the under surface being smooth but not velvety. The flowering spikes are either erect or recumbent, with flowers in clusters of five or seven. The fruits are yellow when ripe and are distinctly three cornered and ribbed. The variety is found somewhat resistant to 'katte' disease. It is suitable for higher elevations than Malabar.

Ceylon.—A robust variety with stems shorter and leaves broader than the others. From the base of the stem to the base of the leaves the stems show a characteristic light pink tinge. The flowering spikes are erect, the fruits are yellowish green when ripe somewhat longish from one to two inches long, and when dry are arched and are darkish brown in colour. The seeds are more numerous, larger and less aromatic. The fruits are much subject to attacks by thrips but the variety is found resistant to 'katte, disease.

Another variety has been distinguished, *viz.*, Elettaria laxiflora, which has the following characteristics. The flowering spikes appear very loose and open, both sub-branches and clusters likewise lacking compactness. The flowering spikes have a recumbent habit. The fruits are up to one inch in length, and are yellow when ripe.

What was called the Ceylon cardamom in one of the Coorg estates was the variety with the erect flowering spikes. The clumps were very large and possessed a very large number of flowering spikes. A Ceylon clump and a local (called the Manjarabad) variety growing side by side under almost identical conditions showed striking differences in growth; the former was a very large bush consisting of 55 stems and having 75 flowering spikes while the latter comprised only 22 stems with 38 flowering spikes. The flowers in the former were also more closely set and a good number had opened about the same time, which indicates more even ripening or at least a reduction in the number of pickings required.

In addition to the cardamom proper there are several other closely allied plants whose seeds resemble the true cardamom in taste and smell. These are (1) the round or cluster cardamom (Amomum kepalage) of Java whose seeds have a camphor-like taste, (2) Korarima cardamom, whose fruits are larger, reddish brown in colour and striated, and the seeds have the taste of the

genuine cardamom, (3) Bengal cardamoms (Aframomum aromaticum) whose fruits are also larger and winged and the seeds taste aromatic and somewhat like camphor, and (4) wild cardamoms (Aframomum xanthoids) or 'Siam Cardamom' whose fruits are spiny and whose seeds resemble closely the genuine cardamoms but have a different flavour.

Pest and diseases.—The cardamom plant is subject to many insect pests and diseases. The insect pests comprise the following:—(1) the caterpillar *Eupterote canaraica M*—which eats the leaves and completely defoliates whole clumps. The hairs of these caterpillars cause painful sores when they come into contact with the human body and make it almost impossible for labourers to work in their midst for cultivation or harvest. These caterpillars are nocturnal feeders; they spend the day on the barks and branches of the jungle shade trees and descend down with nightfall in great numbers and feed on the cardamom plants and crawl to the trees by day-break. The pest is said to occur only in cycles of a few years, the exact number not being known, so that after one or two years of serious infestation they disappear altogether to appear again only after several years. The caterpillars are also severely parasitised by a small parasitic wasp which effectively checks its multiplication. Pupation takes place inside little pellets of earth and frass at the base of the trees; these pellets can be gathered by removing the earth round the trees and passing it through a coarse sieve when the pupae are left on the sieve and can be destroyed. The pest was very severe in parts of Mysore and Coorg during the years 1936, 1937 and 1938.

(2) Thrips (*Toeniothrips Cardanomi R*) are another serious pest. These infest the outside of the fruits from the time they begin to form. The fruits become shrunken and unequally developed and in bad cases are reduced to the size of a pepper corn. Moreover all thrip-attacked fruits show little corky incrustations on the skin which seriously disfigure them and reduce their value considerably. The pest has spread much in recent years and now prevails in nearly all cardamom tracts. No satisfactory remedies are known; though it is claimed that dusting the base of the clumps and the inflorescence with sulphur or pyrethrum powder and spraying with tobacco decoction materially reduce the damage. It has been observed that the pest occurs more on the erect than in the prostrate or semi-erect variety.

3. Both stems and fruits are sometimes subject to the attack of a boring insect—*Dichocrosis punctiferalis, Gn,*—the grubs of which bore into the stem and also into the fruit capsules. The insect is the same one as is found attacking the pods of the castor oil plant by boring into the seed capsules. The remedy suggested is to cut out and burn the affected stems of the cardamoms and in case any castor plant should be growing in the

neighbourhood, to burn the seeds and capsules of these plants as well. In view of the risks of the attack to the cardamom plants it will be well not to let any castor plant grow in the proximity of the cardamom at all, as is found in many estates near the labourers' quarters. Other insects noticed are (*a*) tingid bug (*Stephanitis typicus Dist*) a small insect which breeds in numbers on the cardamom leaves (*b*) a *scolytid* beetle which bores into the seed capsules (*c*) a small fly maggot which bores into young shoots. None of these however causes any serious damage.

In Ceylon the larvæ of a butterfly (*Lampides elpis, Godart*) are said to cause serious injury to the fruits as they breed and grow inside the capsules feeding on the young seeds and when about to pupate, cut out a hole in the fruit through which they leave. Seventy to eighty per cent of the fruits are said to be attacked in bad cases, but ordinarily the loss is put down at five to ten per cent. Catching the butterflies with butterfly nets and the application of wood ash or lime about the base of the plants are suggested as remedies. The butterflies, both male and female, have a conspicuous blue colour, the former with a more brilliant and metallic hue and the latter somewhat dull blue and are said to abound in estates at low elevations.

A serious disease the exact nature of which has not been established is a kind of mosaic (?) in which the leaves and the stems gradually dry up and die. The disease seems to attack plants in all stages, from seedlings in the nursery to well-grown bearing plants in the garden. The disease has not been studied. Spraying with Bordeaux mixture in the belief that it may be a fungus disease beginning from the leaves and proceeding downwards, was reported as not to have kept it down.

In addition to these diseases and pests a good deal of damage is caused by the depredations of large animals. Thus, much permanent injury to the plants is caused by the inroads of monkeys which tear and strip open the clumps and eat the tender portions of both new and old stems. An occasional visitation by elephants spells disaster, and these cause as much damage by trampling the plants as by browsing in them. The ripe fruits are eaten by birds, monkeys, squirrels and rats which sometimes necessitates the picking of the fruits before they are quite ripe be cause if they are left over they will be eaten by these animals before the next round of picking takes place.

Chemistry and uses.—The Indian demand for cardamoms is largely for use as a masticatory, flavouring in cooking, confectionery and for medicinal purposes. The cardamom owes its special properties to a volatile oil, which is present to the extent of four to six per cent in the seeds of the Ceylon cardamoms, and of two to eight per cent in the Malabar cardamoms. The oil is light yellow, viscid, has the strong aromatic odour of cardamoms and a pleasant cooling taste. In has a specific gravity of 0·908, and a saponification number between 30 and 80. The seeds contian

about 10 to 11 per cent of proteids, 42 per cent of carbohydrates, 20 per cent of fibre and about 5·5 per cent of mineral matter.

Production and trade.—The area under cardamoms in India can be put down approximately as a little over 100,000 acres. Travancore has 60,000 acres, Mysore 22,000 acres, Madras 15,000 acres, Coorg 10,000 acres and other areas 1,500 acres.

The figures for the external trade for the year 1938-39 are as below:

Exports—13,202 cwts., valued at Rs. 31,51,691.
Imports—1,055 cwts.

Great Britain, Sweden, Germany and the United States of America took the largest quantities, *viz.*, 1,258; 2,795; 2,334 and 1,230 cwts., respectively. Mysore exported in the year 1935-36 by rail alone about 8,480 cwts. of cardamoms valued at Rs. 10,13,358. In addition there is a large export by road, for which no accounts are available.

V. CORIANDER (Coriandrum sativum).

VERNACULAR NAMES FOR CORIANDER:—*Kannada*-KOTHAMBRI-BIJA; *Tamil*-KOTHAMALLI; *Telugu*-DHANIYALU, KOTHUMERI; *Malayalam*-KOTHUMPALARI; *Hindustani*-DHANIA.

The coriander is cultivated on a field scale for the sake of its seeds and on a small scale for the sake of its green leaves and stems. The coriander seeds of commerce are an important spice in Indian cookery and industrially form the source of coriander oil which is distilled from the seeds. The green leaves and stems are used almost every day in Indian homes for flavouring many of the dishes. The seeds have valuable medicinal properties.

Distribution.—The coriander as a cultivated plant is very ancient, and the seeds are said to have been found in the Egyptian tombs of the tenth century B.C. It has formed a highly esteemed spice credited with medicinal properties among both the Asiatic and the European nations, and the races occupying the North African Mediterranean coast from very remote times. At present, it is cultivated largely in India, in Turkey and Palestine, in Russia and the Balkan countries and in North Africa, principally Morocco. In South India, it is a crop of considerable importance mostly in the black cotton soil tracts, and both Mysore and Madras grow large areas. From both provinces large quantities of the seed are also exported.

Soils—The soils suited to coriander are the black cotton soils and the heavy black clayey soils usually put under rice and forming the bulk of the soils under tank irrigation. It is grown on the red loamy soils also but this is only in a few tracts; the coriander is really a typical black cotton soil crop.

Rotation.—In Mysore, coriander is grown in two seasons, the early season from May to August and the late season from October to January. The crop takes only about three to three and a half months to mature. The coriander forms generally one of two crops on the land, being either preceded or followed by the other crop. There are tracts in which coriander is grown twice in the same year on the same field. In the years when very high prices were ruling for coriander, this practice of growing two crops in the same field in the same year was being largely adopted wherever conditions were suitable. The rotation in the early rainfall tracts is, gingelli in the early season followed by coriander in the late season, or coriander in the early season followed by Bengalgram in the late season. In the late season, other crops are also grown such as late jola, wheat or onions, and garlic, while likewise in the early season onions and garlic are also grown to be followed by coriander.

Coriander, as cultivated in Mysore, is grown as a pure crop. The mixed crop husbandry so common with many crops in Mysore is not practised in the case of the coriander, which in this respect resembles Bengalgram, In the Madras Districts of Coimbatore and Tirunelvely and even in Mysore in the villages bordering Coimbatore, the practice of growing coriander along with cotton almost as a catch crop prevails.

Coriander is grown only as a rain-fed crop, on a field scale. Large areas of rice lands under several tanks are often cultivated with coriander but this is in years where there is not sufficient water in the tanks for the cultivation of rice, and the coriander crop is grown principally with the help of the moisture stored in these retentive soils.

Cultivation.—The crop is sown in the middle of May for the early season crop and in the middle of October for the late season crop. The preparation of the soil for the coriander is of a very ordinary character. In the early rains of April (and for the late season crop in the month of September) two ploughings are ordinarily given, followed by working the bladed harrow, or the ploughing is entirely dispensed with and only the bladed harrow worked. In the black cotton soil fields little or no manure is used, but in the case of the red loams or the black soils of the somewhat loamy types, cattle manure is applied to the small extent that can be spared from the needs of the grain crops and about five cart-loads are given. As in the case of other crops, coriander responds well to manuring which is well demonstrated when the crop is grown as a garden crop.

The coriander seed has to be prepared for sowing by being trampled under the feet, so that the seed splits into two halves. The coriander seed is really the fruit, which consists of two semi-circular locules closely adhering to each other and giving the fruit the familiar round shape. By a little pressure the two locules separate; the small round seed is located inside these locules,

one in each locule. By a trampling or rubbing, the coriander splits into these two halves, and sown in this way, only one plant springs from each seed whereas if the fruit was sown entire, two spring from each fruit. The process has the object therefore of economising the seed and of avoiding too thick a stand of the crop. As compared with other field crops, the coriander takes a long time to sprout, often quite ten days, and this long period is also likely to be further prolonged if the whole seeds are sown instead of being split and sown. At least ten to fifteen pounds of seed will be required to sow an acre.

Coriander is sown either broadcast or in rows. In the former case, the field is set out by means of plough furrows into long sections of about six feet wide and these sections are sown one by one and the seed covered by a light ploughing. The more general practice is to sow the seeds through a drill; the single tyned drill tube is tied behind the plough and the seed is dropped into the plough furrow through the drill; or a regular three-tyned seed-drill such as is used for sowing jola is used. In either case the seeds are sown in lines about nine inches apart. The rows are covered by ploughing an adjoining furrow or by means of the bladed harrow. The surface is stirred with a harrow and the crust broken in case a rain should be received after sowing and a soil crust should form thereafter. When the plants have sprouted and are well above ground, the crop is intercultured with a toothed hoe and before the rows close up, a second interculturing is also given. In about two months, the plants are full grown and in full flower. The fruits are ripe in another six weeks and the crop is then harvested. The plants are pulled out by the roots and are taken to the threshing floor where they are stacked. The crop is threshed either a few days after stacking or are kept for a month and then threshed at leisure. Threshing is by means of trampling under the feet of a team of oxen, or by beating out with sticks. The produce is then screened, winnowed and put out to dry thoroughly in the sun.

Yields.—A full crop yields as much as 1,800 to 2,000 lbs. of seeds while an ordinary crop is reckoned as 800 lbs. The seeds are light and a palla of 100 Mysore seers will weigh only about 93 to 95 lbs. The price of coriander has been fluctuating a great deal. Not many years ago, it soared up to Rs. 25 a palla of 100 Mysore seers and though it came down soon after, it still remained high enough to make the crop very profitable and popular. In recent years, however, prices have come down to less than a sixth of the above figure.

Botany and Varieties.—The coriander plant—Coriandrum sativum—belongs to the natural order Umbelliferea. The plants are thin stemmed, low growing herbs, which grow to a height of 9 inches to 2 feet; the stem is very thin, rounded and hollow, and the full grown plants have often a tendency to bend

and lie flat on the ground on account of the stem being too thin and weak to bear the many branched tops and umbels. The plants are much branched and the stems are either light green or have a purple blush. The leaves are alternate, compound and the petiole has a pair of stipules which sheath the stem at the base. The compound leaves become highly segmented and linear as they reach the upper extremities. Both leaves and stem--as indeed the whole plant—have a strong aroma, for the sake of which the leaves are used in Indian cookery. This peculiar smell or aroma is found most disagreeable by some, being compared to the disgusting smell of the bed bug The name Coriander is descriptive of this smell (being derived from the Greek word 'Koris' meaning 'bug') The inflorescence is a compound umbel and comprises usually about five smaller umbels The corolla is made up of five very small petals which are either white or have a tinge of purple; the flowers are both bisexual and unisexual, the latter being mostly staminate. The flowers possess five stamens and the ovary is inferior and bilocular. The fruit is small and rounded, the surface having longitudinal fine grooves and ribs; when pressed it breaks easily into two locules, convex outside and concave inside, in each of which there is one seed. The fruits are aromatic, due to the presence in them of a volatile oil in amounts varying from 0·2% to 1·0% according to variety.

In cultivated fields two different varieties can be seen, one having a light green stem and the other with a somewhat light purple blush on it. These colours of the stems can be recognised on the flowers also, the purple stemmed plants have slightly purple coloured flowers and the green stemmed plants have completely white flowers. The other characters of the two varieties do not seem to have been studied and it is not known what differences exist between them in regard to oil content and so on.

Pests and Diseases.—The coriander plant is not subject to any serious insect pest. Occasionally some stink bugs are found on the plants but they cause no injury worth mentioning, nor are the leaf eating caterpillars—of which the *Laphygma exigua* is the common one—of any importance. The coriander fruits are subject to the attacks of a boring grub which eats the contents of the growing fruits and leaves them hollow. This is also a very insignificant pest.

The most serious of the diseases of the coriander are (1) a wilt disease which in some years kills a large number of plants, and (2) the mildew; the latter appears when there is much moisture and damp at the flowering time and brings about an almost complete loss of crop. Sulphur dusting, or preferably in the case of the field crop, spraying with Bordeaux mixture should be found effective as control methods, in the case of the mildew. No remedies are known for the wilt disease.

A tumour forming fungus (*Protomyces macrosporus*, Ung,) has been noted in certain places in India, Africa, and Australia which produces tumour-like swellings or galls on the flower stalks, petioles and other green parts of the plant. The damage caused is however insignificant.

Chemical composition and uses.—The coriander seeds (fruits) from different countries vary in their content of Coriander Oil (volatile). Thus coriander from Russia yields from 0·5 to 1 per cent, Italian 0·5 per cent, Morocco from 0·2 to 0·3 per cent and East Indian seed only 0·15 to 0·2 per cent. The seeds have the following composition:—

Water	Albuminoids	Fat (Ether extractives)	Carbohydrates	Fibre	Ash
11·2	14·1	16·1	21·6	32·6	4·4 (Aykroyd)

The seeds have a high Vitamin A (carotene) value. Coriander seeds are credited with many medicinal properties and form a valuable household remedy. They are 'carminative, refrigerant, diuretic, tonic and aphrodisiac'. The seeds are chewed to correct 'foul breath'; they are a sedative, and are thought useful in lessening the effects of intoxicating spirituous liquors.

VI. MENTHYA, Fenugreek (Trigonella fœnum-græcum).

VERNACULAR NAMES FOR MENTHYA :—*Kannada*-MENTHYA, *Tamil*-VENTHAYAM, *Telugu*-MENTHULU, *Malayalam*-ULUMA, *Hindustani*-METHI.

The fenugreek is mainly a condiment crop, the seeds being used extensively in Indian cookery as a condiment or spice, much in the same way as coriander or cummin seeds. The green plants are also largely used as pot herbs, gathered when they are young and tender and long before they begin to flower. Elsewhere as in Upper India and in the Punjaub, it is one of the main green fodder crops, for which purpose it is cultivated along with other green fodder crops in small areas but very generally. Being a leguminous crop, it compares with lucerne and berseem as a valuable green fodder crop, in addition to serving as a soil renovating crop. It is said to be a native to India but is now grown throughout the tropics.

Soils, Rotation.—The fenugreek is suited only to the tracts of moderate or low rainfall and cannot be cultivated in tracts or seasons of heavy rainfall. The crop is grown mostly under irrigation as a garden crop on well drained loamy soils and light alluvial soils. It is grown also as a dry crop on the black cotton soils on a field scale, in sections of moderate rainfall, where it is one of the early and short season crops which are later followed

by the crops of the late season. The crop is grown both in the early rains—when it is raised as a dry crop—and in the late season as a hot whether crop under irrigation, as a garden crop. As a pot herb for the kitchen it can be grown practically at any time during the year.

The crop takes only about 2½ to 3 months to mature and on the black cotton soils it is possible to take a second crop in the same field as a dry crop in the same year, during the late monsoon. On these soils it is sown either by itself or as a mixture with the other early crops like green gram, gingelli, coriander, etc., among which it occupies alternate strips of a few or more rows as may be required. It is followed in the rotation by crops like wheat, Bengalgram or late season jola. Grown as an irrigated garden crop, it is generally followed by a grain crop like jola or ragi or by one or other of the large variety of garden crops.

Cultivation.—On the black cotton soils the field is well prepared by the heavy bladed harrows and the clod breaking and levelling boards during the early rains. About the middle of June or early in July in the slightly moist seed bed the seeds are sown through four-tyned seed-drills, the tynes being about nine inches apart, and the rows are covered by working the light bladed harrow. If sown pure, about 15 or 20 lb. of seed will be required to sow an acre. The seeds sprout quickly and show above ground in three days. Growth is also quick and in the case of its use as a pot herb the plants can be gathered and used from about the third week. On a field scale an interculturing is given early in the second week. The plants begin to come into flower in six weeks but long before this stage, considerable quantities are removed and sold as greens or pot herbs. In about a month or five weeks after the flowering, the seeds mature and are fit for harvest. The plants are pulled out by the roots and brought over to the threshing floor where they are put out to dry in the sun. The pods split easily and are beaten with sticks to free the seeds completely, which are then winnowed and cleaned. They are further dried in the sun before they are stored or sold.

Irrigated Cultivation.—The crop is cultivated more usually as an irrigated garden crop. For this purpose the field, after it is well prepared and manured, is laid out into beds suitable for irrigation. Seeds are sown broadcast, somewhat thickly, at the rate of 25 to 30 lbs. of seed per acre and are well stirred in. The crop is irrigated regularly as required. A good portion is usually removed when young for sale as pot herbs and in Upper India practically the whole crop is removed at the stage when the pods are forming, for use as green fodder. Only a thin stand of the crop is left to mature seeds in both cases.

The yields are very variable, depending upon whether the crop is grown as a dry crop or as an irrigated crop, mixed or pure, and the extent to which it was used before the seeds set.

Grown on a small scale under irrigation, a maximum of about 400 lbs. may be expected per acre.

Botany and Varieties.—The fenugreek—Trigonella fœnum græcum—belongs to the order Leguminoseae. The plant is a herbaceous annual which grows to a height of about a foot. The stem is very thin and rounded and is much branched. The leaves are pinnately trifoliate, petiolate, with two light green stipules. The flowers are sessile and are borne on the leaf axils in singles and are white or light yellow in colour. There are ten stamens, diadelphous and united for the major part of their length. The pod is 3—4 inches long with a long persistent beak; the pods contain 10—20 seeds each.

Chemical Composition and Uses.—Both the seeds of the fenugreek and the green parts of the plant used as pot herbs are slightly bitter to the taste. The seeds are valued both as a spice or condiment and as an article of medicinal value. It is principally as a carminative and tonic in gastric troubles generally that the seeds possess medicinal properties; the seeds are also reputed to increase the flow of milk and on this account are largely mixed and ground with the mash of pulses, cotton seed, etc., prepared for milking cows and buffaloes. The seeds also enter into the composition of many of the 'condition powders' recommended for cattle, sheep and horses. The raw seeds swell up and become highly mucilaginous on soaking in water and to this is sometimes attributed their beneficial action in gastric troubles.

The composition of the seeds is as below:—Moisture 13·7, protein 26·2, fat (ether extract) 7·2, carbohydrates 44·1, fibre 7·2 and mineral matter 3·0 per cent. Among the mineral contents, the seeds contain of calcium 0·16 per cent and of phosphorus 0·37 per cent. (Aykroyd).

Pests and Diseases.—The fenugreek plant is not subject to any serious pests or diseases. It is sometimes attacked by the ordinary mildews and by a rust which is characterised by small brown spots on both the surfaces of the leaves. The name *Uromyces trigonellae* has been given to this rust. The damage due to these two diseases is insignificant. Young seedlings are subject to damping off, when the soil is too moist or there is much rain on the crop.

VII. JEERIGE, Cumin seeds (Cuminum cyminum).

VERNACULAR NAMES FOR JEERIGE:—*Kannada*-JEERIGE, *Tamil*-SIRAGAM, *Telugu*-JILAKARA, *Malayalam*-JOREKAM, *Hindustani*-JIRA.

Distribution.—The 'jeerige' crop is cultivated for the sake of its seeds which are used as a spice in cookery and also in medicinal preparations. They are very much like caraway seeds by

which indeed they have been displaced in European markets. In India, they are largely used much in the same way as, and frequently in conjunction with, the seeds of coriander. The crop is said to be a native of Egypt though in India itself its cultivation is very old. The cultivation now extends over many parts of the world, principally under tropical and sub-tropical climates. In addition to India, Persia, Arabia, Egypt, Morocco and Sicily, China and the eastern Archipelago including Java now grow the crop, and some of them like North Africa and Sicily are also large exporting countries.

Climate.—The crop is capable of being grown from sea level up to high elevations of even 10,000 feet. It flourishes in a somewhat mild climate rather than in the hot plains. It is a somewhat delicate crop and has to be grown under careful garden conditions, with moderate well-regulated irrigation. It cannot stand anything but very light rain-fall during the growing period and is, as a matter of fact, cultivated before the south-west monsoon proper begins and after the heavy rains of the north-east monsoon have come to an end.

Soils.—The soils suited are deep friable well drained loams, the typical high grade garden soils. The soil too requires thorough preparation and liberal manuring.

Cultivation. 'Jeerige' is grown in two seasons, *viz.*, in the early season from about the middle of April, and in the late season from about the end of October. The crop matures in about 90 days.

The soil is ploughed several times, the clods are broken, weeds and stubble roots removed and a fine tilth produced. The soil is heavily manured with some 30 cart-loads of cattle manure per acre. The manure is well worked in and a firm fine well-manured seed bed is produced. The field is now laid out into small beds suitable for irrigation. Seed is sown broadcast at the rate of some 30 or 35 lbs. per acre and is well stirred in with the hand or with a hand rake. The beds are now irrigated carefully, so that the seeds are not floated and carried to the corners of the bed. Germination takes place in five days. The beds are lightly irrigated every day and after a week or ten days thereafter the beds are hand weeded. The plants are now well established and make rapid growth with regular irrigation once in three or four days. In about seven weeks from now the crop comes into flower. Irrigation can now be given at longer intervals of a week. In three weeks more, the crop matures seeds and is ready for harvest. The plants are pulled out and stacked carefully for a couple of days and then are put out to dry in the sun. The seeds are then beaten out and trampled out under the feet of the labourers on a clean floor. The crop is seldom grown on any field scale; yields under the small scale garden cultivation usually practised will amount to about 250 or 300 lbs. per acre on an average and may go up to 400 lbs. in a good crop.

Botany and Varieties.—The 'jeerige' plant—Cuminum cyminum—belongs to the natural order Umbelliferea. It is a slender annual herb, the stems being much branched from the base and very thin in size. The plants grow about a foot in height. The leaves are very thin and linear and bluish green in colour, the petiole sheathing the stem at the base; they are twice or thrice partite, the segments being filiform. The inflorescence is a long stemmed compound umbel. The flowers are white or light red in colour, the calyx is five-lobed and unequally segmented. The fruits (seeds) are thin about 1/5" or 1/6" in length and are laterally compressed, which gives them a kidney shape in a section across the length. There are at least two varieties and probably more but no studies appear to have been made. There is considerable variation in the oil content of the seeds, depending upon the country of origin, which may perhaps be due to varietal differences.

Pests and Diseases.—No insect pest or disease of any importance is noted on this crop. Leaf eating caterpillars are occasionally found and some plant bugs are noticed on the flower heads.

Chemical composition and uses.—The chief use of 'jeerige' is as spice in Indian cookery, it being an invariable ingredient in all curry powders The seeds are used as a medicine and are taken internally either as such or in the form of a decoction. They are also used for external application in the form of poultices.

The seeds owe their aromatic odour to a volatile oil which is present to an extent varying from 2·5 to 4 per cent. Indian seeds are found to contain about 3·5 per cent. The oil has the characteristic odour of the 'jeerige' seed and the active principle giving the odour and the special medicinal properties is cumic aldehyde or cuminol.

The following is the composition of the seeds:—Moisture 12, protein 18·7, fats (ether extract) 15, mineral matter 5·8, carbohydrates 36·6 and crude fibre 5·8 per cent. They also contain calcium and phosphorus to the extent of 1·08, and 0·49 per cent, respectively, and iron 3·10 mgs. per cent. They have a carotene content of 870 units. (Aykroyd).

VIII. MUSTARD (Brassica nigra or Sinapis nigra).

VERNACULAR NAMES FOR MUSTARD; *Kannada*—SASIVE; *Tamil*—KADUGU; *Telugu*—AVALU; *Malayalam*—KATUKU; *Hindustani*—RAI.

The mustard crop is cultivated for the sake of its seed which is a condiment or spice, which is the source of a valuable oil and which finds considerable use in medicine. Though the mustard commonly and almost exclusively grown in South

India is the black mustard (Brassica or Sinapis nigra), there are a large number of species cultivated in other parts of India and in other countries of the world which closely resemble each other and with which the common mustard, is likely to be confused. Thus there is the white mustard, the 'sarson' of Upper India, the rape, the colza seed and several others. One or more of these are grown in many countries under widely differnt conditions of climate, from the tropical to the temperate and even the colder climates. The crop furnishes also green feed and grazing to cattle and sheep and some species are grown almost exclusively for this purpose in certain countries.

The South Indian mustard or black mustard is largely grown as a mixed or subordinate crop along with the main crop of ragi in Mysore. It is seldom or never grown by itself nor is it grown on any large scale. But nearly every one who grows ragi sows a small quantity of mustard along with the grain, with the result that in the aggregate quite considerable quantities are produced in the country. Grown in this way it is solely a rain-fed crop, is cultivated in all classes of soils except the black cotton or black clayey types and is grown in the main growing season *viz.*, from July to November. The method of cultivation, the preparation of the soil, sowing and interculture are all exactly the same as for ragi, and are indeed common to both. ~~In~~ among the rows of ragi the mustard occupies rows about six feet apart, much like the other subordinate crops of 'avare,' niger, fodder jola etc., usually sown along with ragi. The seeds are sown either pure in the rows or these rows themselves may carry a mixture. The number of rows or the proportion of the mustard crop in the ragi is never definite and is decided solely by the needs or wishes of the cultivator. The sowing is simultaneous with the ragi, that is, any time from the middle of June to the middle of August. The seeds sprout very quickly in the moist soil, the seed leaves appearing within 48 hours. The crop shares in the inter-cultivation given to the ragi crop. The crop begins to flower in about 45 days and the pods ripen in another month thereafter, when the crop is harvested. The harvesting is by cutting down the plants or by pulling them out. The harvested plants are then taken to the threshing floor and stacked. They become quite dry in about three weeks and are then threshed by beating with sticks. As already stated, the crop is sown in very indefinite proportions with the ragi and nearly always on a small scale and individual farmers seldom gather more than fifty or hundred pounds. If grown pure (which is very rarely done), about 400 lbs. of seed may be expected per acre.

Botany and Varieties.—The mustard belongs to the order Crucifereae and has been placed in the genus Brassica (or at one time, Sinapis). There are a number of important species in cultivation. The South Indian mustard is a tall herbaceous branching annual growing to a height of 3 to 4 feet with thin

glaucous leaves and stems. The leaves are of two kinds ; the lower ones are large, petiolate and pinnatifid with a terminal lobe, while the upper leaves are small, sessile, lanceolate and toothed. The inflorescence is a long raceme ; the flowers are both terminal and axillary, are yellow in colour, with petals four in number set cruciform. The fruit is a silique and is thin and cylindrical about an inch in length with a thin seedless beak at the end. The seeds, of which the pods contain from ten to twelve, are either black or white. The white mustard plant (Brassica alba) differs in the shape of its upper leaves which are all petiolate. Leaves, stem and pods also differ in being hairy. The young leaves are eaten as a salad along with water cress and the seeds are ground up and form the mustard powder or paste used as a condiment at English tables. The Sarson (Brassica campestris) is also closely similar, has long pods about three inches in length, with numerous yellow or brown seeds. The seeds are largely made use of for extracting oil, which is employed both as a cooking oil and as a lamp oil.

Pests and Diseases.—The mustard crop is subject to attacks by the mustard sawfly (*Athalia proxima K.*) The larvae of this hymenopterous wasp, which are green in colour when they hatch and change later to dark grey and black, feed on the leaves of the mustard and cause much injury. They do not appear on any large scale ; the larvae can be controlled by hand picking in the early stages. If neglected at this time, spraying with stomach poisons will have to be resorted to.

The mustards are severely attacked by different kinds of mildews, which not only appear on and destroy the leaves but are seen on the flower heads and pods, in which they bring about curious malformations. *Cystopus candidus*, *Perenospora parasitica* and *Erysiphe polygoni* are all concerned more or less in these attacks. No remedial measures are known which can be employed on a practical field scale.

Chemical composition and uses.—Mustard seeds are used as a spice or condiment in Indian cookery, both in the raw state and fried. The seeds of various species yield oil from 25 to 35 per cent, which is used as an edible oil, as an unguent and as a lamp oil. The mustards have a biting and blistering effect on the skin and are used on this account for plasters and poultices in medicine. The blistering property is due to a volatile oil (which is also called mustard oil) which is obtained from the seeds after they are ground up with water, allowed to ferment and then steam-distilled. The content of this oil is very small and ranges from ½ to ¾ per cent of the weight of the seed. The oil is a thin, colourless or yellowish liquid, with a strong odour causing tears to flow. When brought into contact with the skin, it raises blisters. Chemically it is mainly made up of allyliso-thiocyanate with very small and variable quantities of allyl-cyanide and carbon bi-sulphide. The substance called "mustard gas", the

dreaded weapon of modern gas warfare, should not be confused with any products from the mustard. It is not derived from mustard at all and is totally different in composition, being Dichlor diethyl sulphide.

The composition of the South Indian mustard is as below:— Moisture 8·5, proteins 22·0, Fats (ether extract) 39·6, carbohydrates 24·0, fibre 1·8, and mineral matter 4·2 per cent (Aykroyd.)

IX. ONIONS (Allium cepa).

VERNACULAR NAMES FOR ONIONS:—*Kannada*-ERULLI; *Tamil*-VENGAYAM, ERULLI; *Telugu*-ULLIGADDA, NIRULLI; *Malayalam*-CHUVANNAULLI; *Hindustani*-PIAJ.

Distribution.—Onions are an important crop grown on a field scale, as well as a garden crop on a small scale. It is one of the few vegetable crops that can keep for a long time and can stand the rough handling of transport by rail or road over long distances, without damage. For this reason like the potato it is a commercial article of considerable importance. Its cultivation is very widely distributed over the world over both the tropical and sub-tropical countries; the closely related species such as the leek and shallot are grown in colder latitudes also. The onion is grown throughout India, and in practically every other country of the world within these zones, and even further north where a period of about three months of warm summer weather prevails. In the United States of America, in the Western, Central and Southern States it is an important crop and in the Central and greater part of South America, in the West Indies, in Spain, Italy and the countries bordering the Mediterranean Sea, in most parts of Africa, in South and North Australia and throughout Southern Asia and the East Indian Islands it is cultivated and forms an important vegetable crop. The crop can be grown over a wide range of conditions from the sea level up to elevations of 6,000 feet, in the warm summer temperatures of the plains and in the cold weather down to temperature of 60°F. It is however not a crop which is suited to the tracts of heavy rainfall and in the cultivating season the rainfall should not exceed 30 inches. It is therefore not suited to the Malnads as a rainy season crop and can be grown in those tracts only after the rains have ceased.

Soils.— Onions require good soils of the garden loam type, free from grit, stones and gravel and well situated for drainage. Both red loams and black rich garden soils, with sand predominating are eminently suited. The crop is nevertheless grown on a variety of soils, including black clayey loams, and even what may be called clayey soils such as are found in the tank-fed rice

lands. In fact over large areas in the Kadur and Hassan taluks in Mysore these are the soils on which onions are grown. These soils are often rich in lime and many fields are even badly situated for drainage. The best crops are grown however in the red sandy loams and also on the somewhat clayey loams under well irrigation, where the soils are usually well worked and well-manured.

Rotations.—Onions are grown almost exclusively as an irrigated crop; the crop is one of short duration and takes from three to three and a half months to harvest. Moreover, onions can be grown both as a rainy season crop and a hot weather crop. All these circumstances permit of two or three crops being grown on the same land; sometimes two crops of onions themselves are taken but more generally the selection is made out of a variety of other suitable rotation crops. Onions are also taken as a catch crop grown in the midst of long duration crops like sugarcane and turmeric. During the first three or four months of the growth of these latter crops, it is possible to grow a crop of onions in the interspaces between the young sugarcane crop, and harvest it by the time the rows begin to close up and the main hoeing, manuring and earthing up are commenced. Sometimes onions may have to be gathered when not quite fully grown but the bulbs reach a moderately saleable size nevertheless. On the tank-fed rice lands of the black cotton soil type referred to, onions in the early season are followed by coriander or jola, in the late monsoon or the latter are grown in the early monsoon and the onions follow in the late monsoon; early monsoon onions are also followed by Bengalgram. Rice or sugarcane may be grown in one year and be followed by onions and coriander, jola or Bengalgram in the next year. A crop of about 45 or 50 days, duration like French beans is sometimes taken in between these two crops making three crops in a year, on the same land, each grown by itself and not as a mixture. In the areas under well-irrigation many crops are grown in the rotation, two crops being almost always grown on the same land, if not three. Irrigated ragi and onions may follow each other, the former in the early monsoon and the latter in the late monsoon. Onions in the early season may be followed by maize and this by potatoes in the late season. Chillies in the rainy season is followed by onions in the late season, or chrysanthemums can take place of the chillies in the rotation. Short duration ground-nuts, French beans and other vegetables are also rotated with onions as one of the two or three crops of the year. If the area is one where tank irrigation is available and well-irrigation is only supplementary, then a crop of rice is taken once in two or three years, one of the objects being to kill out the weeds which persist in garden cultivation.

Onions are also grown very often with an admixture of garlic; in that case the garlic crop is planted alongside the ridges

dividing the irrigation beds while the onions are grown in the beds or *vice versa*, depending upon which of them is chosen as the main crop.

Cultivation.—The cultivation of onions comprises two parts, *viz*, the cultivation for the sake of the (1) bulbs, and (2) the seeds. By far the largest bulk of the cultivation is for the sake of the bulbs, the edible article for which the onion is in demand. But these bulbs can be raised only from the true seed, or from seed bulbs obtained by planting the true seed. Onions have therefore to be cultivated for the sake of these seeds. The true onion seed does not retain its vitality for over a season and hence has to be fresh. It is therefore usually raised in or about the onion growing tracts and very often by the very persons who cultivate onions for the bulbs, and who raise seed at least enough for themselves, but generally for sale also.

Starting with these true seeds, a crop of bulbs is raised which is sold partly as bulbs for edible purposes and partly for seed purposes, that is, for planting as seed bulbs for raising a crop of large bulbs. These ripe and full grown bulbs when planted again bear flowers and mature seed, forming true seeds again for the raising of bulbs. In some villages both these stages in the cultivation are carried out by growers but in others, growers confine themselves to the raising of large size bulbs which are used for direct consumption, and purchase for this purpose seed bulbs raised from true seed.

The planting of the onion crop takes place about the middle of May to the middle of June for the first crop and about the middle of November to the middle of December for the second crop. In both seasons both bulbs and true seeds are raised by planting seed bulbs for the former and ripe bulbs for the latter. When bulbs are planted, a certain amount of economy is practiced in some tracts by cutting the bulbs into two across the middle and planting only the lower half, the upper half being used for edible purposes.

The field for planting onions has to be thoroughly prepared, either by digging if on a small scale, to a depth of nine inches or a foot, or by ploughing several times. Clods are broken, roots and weeds removed and the ground levelled. Cattle manure is applied at the rate of ten cartloads per acre and well worked in. The field is now laid out into beds for irrigation. These are made small in some villages ($4\frac{1}{2}' \times 1\frac{3}{4}'$) or the beds are long narrow strips about six feet wide and divided by the irrigation channels. In these beds seed bulbs are planted at distances of 4 to 5 inches apart each way. On some of the heavier types of black cotton soils the field is laid out into furrows and ridges of nine inches width, and the bulbs are planted on the ridges in three rows, two along the margin of the furrows in the slope and one along the centre of the ridge. In the case of the long narrow strips, the seed bulbs are sown broadcast and covered by

a light ploughing. The beds are now watered. Subsequent irrigations are either by flooding or in some places by means of hand watering. Young shoots appear above ground in the course of ten days and then grow rapidly. The field is hoed and weeded once after three weeks and again after a fortnight. After the first hoeing more manure is given at the rate of another ten cartloads per acre. The fields are regularly watered as required, taking care to see that the moisture is not excessive. In some villages where cultivation is very careful and thorough, the rows of the onions are earthed up at the second hoeing and some little oil cake manuring at the rate of about 10 cwts. per acre is also given. In 3 to 3½ months the crop becomes ready for harvest. The tops begin to wither and yellow and fall flat over the ground and a portion of the ripe bulbs also shows above ground. The bulbs are now dug up; after cutting off the leafy tops and trimming, they are piled up and kept covered with the leaves for a few days when they dry a little and become firm. They are either sold immediately or stored in large airy rooms, spread on the dry floor.

In certain sections (such as in Hunsur taluk, Mysore) in the heavy black cotton soils which are highly retentive, onions are grown as a dry crop. For raising seed bulbs the true seed is sown about the middle of May on fields well ploughed and well prepared. The seed is sown broadcast thinly at the rate of about 30 lbs. an acre. The crop is hand weeded and thinned where it is too thick and blank spaces filled in. About the beginning of August the crop is harvested and the small bulbs are either sold or more often used for planting. These bulbs are planted in separate fields kept prepared for the purpose in the beginning of September, that is, about a month after they were dug. They are planted in shallow furrows about four inches apart and three inches from each other in the furrows. The crop comes up with the help of the moisture stored up in the soil, supplemented by rains, if any, though these rains seldom occur in this tract. The crop matures early in January.

The above refers to the raising of onions by the planting of seed bulbs. A second method is to sow the real seed of the onions and raise either seed bulbs or large bulbs. For this purpose the field is prepared, laid out into beds in the same way as described already. The true seeds are sown broadcast in these beds and are stirred in by means of hand hoes, so that the seeds are sown at a depth of an inch or an inch and a half, the seed rate being about 30 lbs. per acre. The beds are irrigated generally by hand instead of by flooding; the seeds begin to sprout in about 10 days, and if weeds spring up within this time they are removed by a light weeding. Sowing is also done in lines about 4 inches apart and the seeds dropped at distances of 2 inches or less in the rows. Sowing in these lines makes subsequent weeding easy and renders thinning unnecessary.

When sown broadcast the plants come up very unevenly and have to be thinned out in some places and planted in other places where there may be blanks. With regular irrigation, the bulbs are fit to be moved in three months when they are harvested and used for edible or for seed purposes.

Another method which is very commonly practised in certain areas is that of transplanting one month old seedlings from a nursery raised from the true seed. For this purpose the true seed is sown in the same way as described above for raising seed bulbs, except that the sowing is somewhat thicker. One month old seedlings are carefully lifted and transplanted into beds well-prepared and manured in the same manner and at a distance of 4 inches each way. These beds are given the usual hand weeding and hoeing and regular irrigations. The bulbs are ready to lift in about three months from transplanting.

For the raising of the true seed, the method of cultivation is the same as for raising bulbs, with the important difference that large thoroughly matured bulbs are planted. These send up a flowering stalk, usually one but sometimes two, after about two months' growth, at the tip of which a large cluster or umbel of flowers is borne. These set and ripen seed in another six weeks, when the heads are harvested, the seeds well dried in the sun and preserved. In this method the same economy of cutting the bulbs into two across their middle and using only the lower half for planting is sometimes practised. About 800 to 1,000 lbs. of seed is obtained per acre, but usually crops are raised in only small areas of 1/10 or 1/20 of an acre.

Yield.—The yields of onion bulbs from seed sown crops will vary a great deal; under good irrigated conditions and with proper manuring on good loamy soils about 15,000 lbs. are expected per acre, one half or 7,000 lbs. per acre may be taken however as an ordinary yield. Where small seed bulbs are planted an yield of about five to ten fold may be expected. About 1,500 lbs. of small bulbs are often sown per acre and the yields may go up to 15,000 lbs. as a maximum and about one half of this quantity as an average. In the areas where it is grown as a rainfed crop, the yields seldom go higher than three or four fold. Freshly harvested onions lose weight in storage, which may go up to 20 or 25 per cent depending upon its condition at harvest and the season of storage.

Cold storage of onions.—Onions are stored for fairly long periods so that they can be sold when prices are higher than at the time of the harvest. The storage consists merely in keeping them spread on the floor, on racks or in baskets in cool, well ventilated thatched sheds or rooms. Frequent inspection and the removal of rotting bulbs and turning over of the stored product are necessary, the loss due to rotting and driage is considerable and may go up to even 40 per cent, though with care it can be kept down to 15 per cent or 20 per cent. Another

source of loss is due to the sprouting of the bulbs. Kept in cold storage these losses may be greatly minimised. Very low temperatures are not necessary. Thus it was found in cold storage experiments carried out in Poona that at 90 to 95 degrees F., the bulbs remained healthy even after six months of storage, did not sprout at all, formed no roots and lost weight by driage only to about 21 per cent. Comparative lots kept at low temperatures of 32 degrees F., showed that both sprouting and root formation occurred, but that the loss due to driage was only 10 to 12 per cent. The bulbs stored at the higher temperature of 90 to 95 degrees sprouted more readily after being taken out of storage than those kept at the low temperature of 32 degrees.

Botany and Varieties.—The onion plant belongs to the natural order 'Liliaceae' and is distinguished botanically as Allium cepa. The onion itself is a 'bulb' which is composed mainly of thick fleshy leaves enveloping and surmounting a flat disc-shaped 'stem', from the bottom of which spring the roots of the plant. In the interior of the bulb and springing from the centre of the disc is the small young shoot which eventually emerges and grows as the green leaves of the plant. These leaves are thick and fleshy, long and linear and possess the same characteristic smell of the onion, which is specially noticeable when the leaf is bruised. The roots are fibrous and spring radially from the base of the stem and have a somewhat shallow range. The bulbs are borne very close to the ground and when maturing are generally partially visible above the ground. The mature onion sends out a flowering stalk which is straight, hollow and tapering towards the top where it bears a rounded cluster of flowers resembling an umbel. These flower stalks are sometimes cut and used, cooked as a vegetable, and have the same flavour and taste as the onion itself. For this purpose the stalks are cut before the flower head opens. These flowers are sometimes also removed before they open or the stalks themselves twisted off or broken by trampling, in order to increase the size of the onion bulb underneath. The flowers which are bisexual, are inconspicuous except for the striking shape of flower head; the stamens are six in number, the ovary is superior, formed of three carpels and the fruit is a three-celled capsule. The onion seed is black in colour, somewhat triangular in shape, is small being about the size of a third of a pepper corn. The seeds also possess the characteristic odour of the onion which is perceived when they are squeezed between the fingers. The onion is a cross-fertilised plant and 'selfed' flowers do not set seed. The flower heads sometimes bear small bulbs in the places where a flower is ordinarily formed, and these little bulbs are often preserved and used as planting material. Some bulbs send out two flower heads, the second appearing after the capsules of the first are fully formed. The early appearing flower heads give seeds which are heavier and have higher germinating capacity than those from the later flower head.

There are several varieties grown in South India which are distinguished mostly by the difference in the size, colour and the strength of the flavour of the bulbs. There is firstly the large type called 'Yedugiri' or 'Bellary' onion which is flesh coloured and attains a size of about three to four inches across. There is the large white variety called 'Dhulia' which is grown much in the Bombay Presidency and to some extent in the Northern and Western Districts of Mysore. This is almost of the same size as the Yedugiri or Bellary onions in good specimens but generally somewhat smaller. There are the medium kinds, both flesh coloured and white; the former is the great commercial variety in Mysore grown largely in the Bangalore and Kolar Districts and extensively exported outside as far as Ceylon. These onions are about two inches across and strongly flavoured. The white variety of this type is grown only to a small extent and is often a rarity. There are again the small sized onions of which two are recognized, one somewhat longish and the other globular and almost round. These are all very strong flavoured, they also have the habit of growing in bunches containing three or even four bulbs per plant. These are fancied for pickling and are called pickling onions; they are used in curries, boiled entire. In other countries very many varieties are recognised, which differ in size, colour and shape and keeping qualities, suitability to different conditions, and above all in the taste and flavour. In California, for example, as many as eighteen varieties are listed and grown. Plants in which the leaves, or bulbs or both bulb and leaves possess the onion flavour and are used in cookery for the sake of their flavour are the Shallot, Chives and the Welson onion.

Pests and Diseases.—The onion is comparatively free from major pests of any kind. It is subject to the attack of thrips, which feed on the foliage, sucking the sap and lacerating the leaves. They are easily controlled by spraying with tobacco decoction. Crops with good cultivation, irrigation and manuring are not much affected.

A leaf-eating caterpillar (*Laphygma exigua, H.*) is sometimes found attacking the crop. The remedy consists in hand-picking the caterpillars and in pinching off the shoots when the caterpillar remains inside these tubular leaves.

The onion is subject to a kind of rust, which appears as yellow rusty spots on the leaves, weakening the plants and greatly reducing the crop. Plants are sometimes killed out when the attack is serious or appears early.

Chemical composition.—The characteristic odour of onions is due to its content of a volatile oil which possesses the pungent and persistent odour of onions and which is present to the extent of 0·046 per cent in the whole plant. The oil is a dark brown mobile liquid, the principal constituents of which are two closely

allied disulphides. The bulbs have the following composition.

Variety	Water	Albuminoids	Oil	Carbohydrates	Fibre	Ash
Large ...	86·8	1·2	·0	11·6	0·18	0·4 Aykroyd)
Small ...	84·4	1·8	0·1	13·2	·0	0·6 (do

X. GARLIC (Allium sativum).

VERNACULAR NAMES FOR GARLIC:—*Kannada*—BELLULLY; *Tamil*—VELLAIPUNDU, ULLIPUNDU, *Telugu*—TELLAGADDA, VELLULI; *Malayalam*—VELLULLI, *Hindustani*—LASUN.

Garlic which is an important spice or condiment crop possessing at the same time valuable medicinal properties is grown throughout India.

Soils and Rotation.—In respect of soils, climate, rotation and methods of cultivation garlic is very much like the onion crop, and in fact garlic is often grown in the same beds in which onions are grown, the latter occupying the margins of the beds with the garlic as the main crop. Garlic takes a longer period to mature than the onion and has to remain in the field for nearly five months. Unlike onions moreover it is grown mostly as a late season crop from the months of September-October onwards, and is planted in the early season only to a small extent. It is grown also only as an irrigated and not as a purely rainfed crop as onions are cultivated in many places. Well drained moderately clayey loams are the best soils for growing garlic but the heavier soils of the black cotton type are also sometimes put under it.

Garlic is grown under irrigation and a good irrigation source which can supply sufficient water for frequent and regular irrigation should therefore be available for its cultivation. It is grown as a garden crop on a small scale under well irrigation and on a field scale in tank-fed or channel-fed areas. The crop takes about five months to mature and in Mysore it is grown both as a 'mungar' or early season crop and as a 'hingar' or late season crop. For the former the planting season is the early part of the month of May and for the latter the early part of October. It is generally rotated with irrigated ragi, chillies, maize, potatoes and beans, chrysanthemums and similar crops usually grown under well irrigation. Large areas are grown on black heavy clay loams and on soils of the black cotton soil type under tank irrigation (Hassan and Kadur Districts in Mysore). On these soils the garlic is sometimes grown in two seasons successively in the same year, and sometimes for two years in the same way, and followed in the second year, or in

the third when two years have been devoted to garlic, by a crop of rice. Commonly however the garlic is grown only once in a year either in the early season or in the late season. In these cases it is rotated with coriander, the pulses, blackgram, greengram, Bengalgram, and the grain crop Bilijola. Once in two years at least a crop of rice is cultivated as part of the rotation.

Cultivation.—The method of cultivation in these tank-fed areas is as follows :—The fields are ploughed twice, then worked with the bladed harrow to break the clods and bring up weeds and roots and stubble which are then gathered by hand or by a light harrow and burnt. Cattle manure at the rate of ten cart-loads an acre is spread and worked in with the bladed harrow and the field levelled with a levelling plank. The field is now laid out into long beds by ploughing a deep and wide furrow at distances four and a half to six feet apart. In the long beds so formed, the garlic is planted either regularly in shallow furrows or is sown broadcast and stirred in with a light harrow.

The planting material is prepared by pulling the garlic bulb asunder and separating the little flattish bulbs of which it is composed. The garlic bulbs as ordinarily seen are composite bulbs made up of several small flattish bulbs which are tightly covered over and held together by the whitish dry papery scales forming the lower portions of the leaves. This papery covering is pulled apart and removed to get at the little bulbs which form the planting material or seed bulbs. The composite bulbs are trampled under foot on hard ground and rubbed between the hands to remove the covering. The material is then winnowed a little to get rid of the bits of the covering. Small and ill-developed bulbs are discarded and only good ones are selected for seed. These seed bulbs are sometimes spoken of as 'cloves'. An acre requires generally about 250 to 300 lbs. of seed, in this method of cultivation.

When planted in furrows, the furrows are made with a small hand rake or harrow, or by means of a small hand hoe, at distances of six inches from each other across the beds, and the 'cloves' or bulbs are dropped about three or four inches from each other in these furrows and covered with the hand. In broadcast sowing, the bulbs are strewn by hand, and then covered by working the light bladed harrow, and furrows dividing the beds are ploughed later on at distances of about 4½ feet, water is then let in and the field flooded. In about three days thereafter when the surface of the field is fairly dry, the levelling board is drawn over the field to press the soil firmly over and around the seed bulbs. At the same time any seed bulbs which are showing above ground are pressed into the mud. This same work is sometimes accomplished by people trampling in the beds and pressing the extra bulbs showing aboveground into the mud. The field is now given another irrigation and once

in fifteen days thereafter the field is irrigated. After the bulbs have all germinated, the uneven stand is rectified by thinning out crowded patches and transplanting in sparsely sown areas. Two hand weedings are given during the first two months, at the end of which period the bulbs begin to swell. From this time watering is given once a week or ten days. At the first hand weeding a light top-dressing with artificial manures at the rate of one cwt. of sulphate of ammonia mixed with the same quantity of superphosphate of lime can be given with advantage. In about 120 days the crop begins to mature, the leaves begin to yellow and even the bulbs begin to appear slightly above ground. Very often the plants send up a flowering stalk, these stalks bear both flowers and a number of little 'bulbils' as in the case of the aloes. Although the bulbs do not become spoiled on this account, the crop should be harvested. The field is irrigated a few days before the harvesting in order to soften the soil and to make harvesting without damaging the bulbs easy. Harvesting is by digging out the plants with the bulbs intact. After the crop is dug out, it is washed to free the bulb from adhering earth and tied together in small bunches by their tops or leaves, and then put out to dry in small heaps on the fields for a few days. They are now trimmed by cutting off their tops and much of the roots and are taken indoors where they are thinly spread to dry. Instead of leaving the untrimmed plants in field heaps, the bundles may be taken indoors and hung from over-head poles or from the ceiling in the house until they are quite dry. The trimming and cleaning may be done prior to taking out the produce to the market.

When the crop is cultivated under well-irrigation, the soil is prepared by deep digging; it is heavily manured, sand or tank silt is carted according to the nature of the soil and the bulbs are planted closer in carefully made irrigation beds, without wasting much space. The seed rate is much higher and is about 500 lbs. per acre.

Yield.—The yields of garlic are generally low as cultivated in the tank-fed areas referred to; an ordinary yield is only about 1,500 lbs. per acre, and a good yield may go up to 2,500 lbs. per acre. Where two garlic crops are raised in the same land in one and the same year, the total yield may not go higher than 2,500 lbs. for the two crops together. The early season crop gives (*i.e.*, the first crop) about 1,500 lbs., and the second or the late season crop gives only about 1,000 lbs. In garden cultivation under well-irrigation, the yields are much higher and go up to 7,000 lbs. per acre. Though these are the yields usually obtained in the Mysore State, elsewhere, as in the Bombay Presidency, the yields are very much higher and so is the seed rate. About 700 lbs. of seed bulbs are sown per acre and yields of 8,000 to 10,000 lbs. are obtained. As a rough estimate, the yield expected is about ten times the quantity of the

seed sown, higher yields than this being obtained with better soils, cultivation and heavier manuring.

Botany and Varieties.—The garlic—Allium sativum—belongs to the natural order 'Liliaceæ' and is closely allied to the onion. The aboveground portion of the plant is only the leaf shoots; the real stem is a flattish disc inside and at the base of the garlic 'bulb' from which roots emerge below and scale-like leaves above, in the axils of which are borne the little bulbs or 'cloves' making up the garlic bulbs which are therefore compound bulbs. The leaves are long, linear and flat, bluish green in colour, springing from the cloves or little bulbs which are really tubers or swollen stems. The roots are fibrous, traversing generally to a depth less than a foot and radially about nine inches. The garlic sends out a flowering stem which bears at the top an umbel of flowers and dimunitive bulbs (or bulbils). The scape is slender and the spathes long beaked. The flowers are small and inconspicuous; the sepals are greenish white, slightly tinged purple and lanceolate; the stamens are not exserted from the perianth and the teeth of the inner stamens are not longer than those in the centre which bear the anthers. The stamens are six in number, the ovary superior and three-celled. The seeds are small, black and with flattish compressed sides.

No distinct varieties are cultivated. A distinction is however made between large and small bulbed kinds, the kind grown in Mysore being considered larger than the one cultivated in the plains. It cannot be stated definitely if these are distinct varieties.

Pests and Diseases.—There are very few pests and diseases attacking garlic. The Thrips (*Thrips tabaci, L*) which attack onions also attack garlic and sometimes cause serious damage. They lacerate and puncture the leaves sucking the sap and weakening the plants. The pest can be controlled by dusting with tobacco dust or spraying with tobacco decoction.

The mildew—*Oidiopsis taurica* (Liv.) *Salm-Erysiphe, taurica Lev.*—which attacks chillies and brinjals also attacks garlic. The attacked plants are greatly weakened by the leaves drying up. This fungus unlike other forms of mildew is favoured by warm or dry weather. It is also more deep seated and cannot be treated by sulphur dusting or spraying with potassium sulphide solution, as in the other forms of mildew. Bordeaux mixture spraying will however prevent the fungus spreading to healthy leaves and plants.

Garlic is also subject to another fungus disease—*Alternaria palundi*—which is sometimes very serious. Spraying with Bordeaux mixture will however keep down the disease.

Chemical composition and uses.—The garlic is used as a condiment or spice and to an equal extent as an medicinal article. Its use as a condiment is itself, as a matter of fact, due to its

medicinal properties. These are said to comprise digestive, carminative, and anti-rheumatic properties; as a tonic for the lungs, for healing intestinal ulcers, as an important specific for the disorders resulting from child birth, as a specific in sore eyes, for muscular pains, giddiness and a number of other ailments it is a popular household remedy.

The garlic owes its peculiar odour to the presence of a volatile oil, of which the whole plant when distilled yields about 0·005 *to* 0·009 *per cent*; the oil is a compound consisting of carbon, hydrogen and sulphur.

The bulb has the following chemical composition:—

Water	Albuminoids	Carbohydrates	Fat	Crude fibre	Ash	Remarks
64·0	6·76	26·3	0·06	0·77	1·44	(C. Wehmer)
63·0	6·30	29·0	0·10	0·80	1·00	(Aykroyd).

SECTION VII.

FIBRE CROPS

I. COTTON

VERNACULAR NAMES FOR COTTON; *Kannada*—HATHI; *Tamil*—PARUTHI; *Telugu*—PARTHI; *Malayalam*—PARUTHI; *Hindustani*-KAPPAS, RUI.

The cotton crop is grown for the sake of its fibre, and it supplies the most important primary requirement of mankind next to food, *viz.*, raiment. It is the oldest among the commercial crops of the world and its cultivation has always connoted a high degree of civilisation when the arts of spinning and weaving were known and practised. Though its use as clothing for mankind is the chief purpose for which it is cultivated, cotton is used for a number of other purposes as well both in the shape of fabrics in which it is used by itself or in mixture with other fibres and in the shape of industrial products. Consequent upon the large over-production in recent years and a shrinkage of the demand in the accustomed channels, the use of cotton for many other purposes has been greatly stimulated. Cotton may be said to be the most extensively grown commercial crop of the world.

Distribution, Climate.—Cotton is essentially a tropical crop but its cultivation is carried on successfully over many parts of the world, far removed from the tropics. The limits of cultivation may be said to be the 30th or even the 40th latitude. on both sides of the equator. Thus India, China, Iran, Iraq, Southern Turkestan and Russia, Asia Minor, Egypt and the greater part of the African continent, the Southern States of the U. S. A., Central America and Mexico, Brazil, the West Indies, Australia and the South Sea Islands are all countries where cotton is cultivated. It is estimated that 65 per cent of the world's supply comes from the U. S. A., some 15 per cent from India, 6½ per cent from Egypt, 4½ per cent from Russia and the remainder from the other parts of the cotton growing world. Cotton is grown either at sea level or at moderate elevations not exceeding about 3,000 feet. Its cultivation is largely confined to flat open country, and rough hilly tracts and high altitudes are not suited. In the latter sort of country it can be grown only where the prevailing climate is almost tropical during the growing period of the crop, with the temperature not going lower than about 70°; higher temperatures are very favourable and the upper limit may go up at any rate during the picking season to about 105°. The cotton crop cannot stand anything but a moderate rainfall.

Rainfall exceeding about 35 inches should be considered not favourable for cotton. On the other hand it can be grown even under conditions of low rainfall, provided the soils are retentive, and, if irrigation is available, even under conditions of very low rainfall. The lower limit of rainfall for a purely rainfed cotton will be about 20 inches. On the black cotton soils and with the varieties usually grown on these soils it is remarkable that hardly any rain is needed during most of the growing period of the crop. Once very good rains have been received prior to the sowing of the crop, the soil well soaked to a good depth and the crop has had a good start, then it can grow and mature a fairly normal crop without any further rainfall, depending solely upon the moisture stored in this type of soil. On the red soils a better rainfall will be required which should be also well distributed over the crop season. To this type of soil and for the shallow—rooted varieties usually grown on them, a rainfall of at least 20 inches will be required in the growing season. Cotton is grown both as a dry crop and as an irrigated crop.

Soils.—The typical soil on which cotton is largely grown in India is called the 'black cotton soil'. This kind of soil occupies large stretches of flat open country often for many square miles in extent and this situation is such as to make one think that it may be the sediment of immense lake bottoms which may have gone dry ages ago. The water holding capacity of these soils is great and they are exceedingly retentive of moisture also. The soils are black in colour varying from those with a tinge of slight ashiness about them to those that are deep black. They are very clayey in texture in the sense that when wet they become very sticky; walking or driving on these soils after a rain is very inconvenient as with every step or every turn of the cart wheel large masses of the wet mud stick to the feet or the wheel. When they dry they are however quite different from typical clays, because unlike clays which set hard under such circumstances, this type of soil crumbles to powder; in fact the top soil is loose and is often in sufficiently good tilth to permit of sowing. Like clays morever they shrink in volume when they dry; the surface cracks in the hot weather and these cracks extend deep and wide, especially if the soil is one of much depth. They are also characterised by the presence in them of small nodules of limestone, to which the name 'kankar' is applied. These limestone pieces may be small rounded ones or thin finger-like masses three or four inches long. This lime content is indeed very characteristic and marks them off sharply from the red and light red soils and other ordinary soils, even though these latter may be black in colour. The lime content may go up so high in certain stretches of the black cotton soil tract as to make them marly and practically unfit for cultivation. Black cotton soils are esteemed very fertile and with increasing depth their value is enhanced. In depth they may vary from a foot or 18

inches up to even 10 feet, the whole mass being almost uniform in character. They are underlaid not by any single particular type of rock but by a variety of them, such as decomposing gneisses and granites, quartzites and chlorite schists and they may adjoin highly decaying rock masses crumbling loose with pegmatite crystals and felspars. A low rainfall is generally characteristic of the black cotton soil tracts as well as high atmospheric temperatures, and during summer the heat from radiation in the tract is great, all of which are conditions which may be described as arid. Their mode of origin and the nature of the constituents which give them their typical black colour are not well established. Their content of organic matter as represented by the loss on ignition is somewhat higher than in red soils and to this the colour partially at least is to be attributed. Many of them contain titaniferous magnetite particles which may also to some extent account for the colour. The iron too is suspected to exist in some form of organic or other unknown form of combination, which may impart a black colour to the soil. This black colour is apparently a stable condition; nowhere have instances been seen of any reduction or change in the depth of colour due to weathering agencies. It is thought by some that red soils themselves have, as the result of very moist conditions or submergence, been transformed into black soils or that the latter have been formed under these conditions without the intermediate formation of red soils. It seems however probable that the two are derived from rocks of different composition, although of the same group such as granite and gneiss. The black cotton soils are probably derived from calcareous felspars while the red soils are derived from potash felspars. The concretions of limestones of different sizes and shapes are probably due to the material dissolved out by water containing carbonic acid and retained in the soil under the semi-arid conditions prevailing in such tracts with no heavy rains to reduce the quantity by leaching. Vast stretches of black cotton soils characterise the Deccan trap regions in West Central India, being obviously derived from that easily crumbling and weathering type of rock. The composition of the black cotton soil is not always uniform, but the following may be taken as a typical specimen:—

Insoluble residue—79; Iron and Alumina (Fe_2O_3, Al_2O_3)—10; Lime and Magnesia (CaO, MgO) — 5·5; Potash (K_2O) — 0·5— Phosphoric Acid (P_2O_5) — ·05; Nitrogen — ·04.

Cotton is also grown largely on other types of soils, such as red, light red, and ashy coloured loams; gravelly, stony or sandy soils are avoided; loams are usually of the lighter and well-drained type and not clayey and likely to become too wet. Alkalinity and insufficient drainage are very harmful and cause

not only poor growth of the plants but also leaf and boll-shedding even in well-grown crops.

There is a somewhat sharp distinction in regard to the kinds of cotton that can be and are generally grown on these two broad classes of soils, *viz.*, the black cotton soil and the red and light coloured soils. The indigenous or 'Asiatic' cottons are grown almost exclusively on the black cotton soils. The cotton called 'Roseum' is however an exception and is grown on a variety of soils, including even coarse, stony and gravelly red soils. The 'New World' cottons represented by the 'hirsutum' types are grown on the red soils and the soils other than the black cotton type. Black cotton soils are not avoided but the crops on such soils are generally uncertain and poor, although in favorable seasons very good crops are obtained. The 'New World' cottons are extensively grown under irrigation and for this purpose only the soils other than the black cotton soils are selected; the bad effect of irrigation due to lack of drainage and a too close soil structure become accentuated on the latter type of soils which are hence generally avoided. The 'New World' cottons are thus grown on both kinds of soils when grown as rainfed crops but under irrigation mostly on the red and light red soils only.

Rotations.—The rotation for cotton differs according as it is grown on the black cotton soil or on red soils and in the former case according to the extent and distribution of the rainfall and to the variety of the cotton grown. If the rainfall is distributed over both the monsoons the extraodinary fertility of the black cotton soil allows of a wide variety of crops being grown and also of the taking of two crops in the year, one in the S. W. Monsoon and other in the N. E. Monsoon. If on the other hand the rainfall is low and is confined to the N. E. Monsoon as is the case in many black cotton soil tracts, then only one crop can be grown in the year. In the former case the crops that are generally grown on the black cotton soils are cotton, jola, groundnuts, tobacco, chillies and even ragi as the main crops and where two crops are grown, the second crop may be one out of a large variety such as, blackgram, green gram, Bengal gram, 'gingelli,' wheat, 'bilijola,' coriander, etc. When the main crops are grown they are the only ones of the year and no second crop is grown. In this case the rotation generally is, cotton in the first year and jola in the second. The stretch under cotton is in recent years largely divided between cotton and groundnuts, the latter of the short duration Spanish and Small Japan varieties. Depending upon the market for either crop the areas under the two are suitably apportioned, so that either the one or the other occupies the larger area. Although as the important food crop of these tracts, which at the same time furnishes abundant fodder for stock, jola continues to be grown on half the extent of the holding, still when the prices rule high for cotton and groundnut, then these may be grown on larger areas at the

expense of the area normally under jola. The short season groundnuts are followed by horsegram in the same year; the horsegram in this case is drilled between the rows of groundnuts about a month prior to the harvest of the groundnuts. Small areas are devoted to tobacco and to chillies as the main crops of the year in the cotton or groundnut stretch, and in certain sections of the black soil tracts these assume considerable importance and the areas under them may occupy several acres of a man's holding without however reducing the area under jola. Where the raising of two crops is possible then one or more of the crops blackgram, greengram, gingelli or coriander are grown as the early season crop. All these are short duration crops and are harvested in time for a second crop to be raised in the N. E. Monsoon. The latter comprise Bengal gram, wheat, 'bilijola', and coriander. Bengalgram follows only a non-pulse crop such as 'gingelli' or coriander, wheat and 'bilijola' follow any one of the above crops whether pulse or non-pulse, and the coriander follows any crop other than itself, when raised as a first crop.

In the regions where the rainfall is mainly in the N. E. monsoon only one crop is grown in the year and the rotation is, cotton (indigenous) followed by 'bilijola'. The 'bilijola' is the type of jola which is early maturing and giving good yields of both fodder and grain; the fodder can be used both as green fodder and as dry fodder. The variety of cotton grown in this season is only the indigenous cotton and not the New World cotton—'doddahatti' or Dharwar American. Where the season is too late for cotton on account of the rains being late, then cotton is omitted altogether and 'bilijola' alone is grown, even though the previous year's crop may have been 'bilijola'. Bengalgram is a crop of this monsoon and part of the area may be cultivated with this pulse. A common rotation in South India is jola-cotton-'sajje' (called' 'cumbu' in Tamil). The jola is grown for fodder and 'sajje' is the food crop. It has been observed in regard to this rotation that the cotton crop following jola is somewhat adversely affected and that the yield is much less than when cotton follows 'sajje'. The adverse effect can however be prevented or reduced materially if the jola is cut at the short blade stage and thus not allowed to mature grain. In Mysore the cotton-jola rotation is the recognised and most common rotation and no such harmful effect is complained of. The jola grown is however not the fodder variety of jola but a grain type.

The grain crops of the black cotton soil tracts are jola, 'navane' and 'sajje'; ragi is also grown but to an insignificant extent. In Mysore jola and 'navane' are the grains *par-excellence* on these soils. In addition to the rotation of crops there is the practice universal in Mysore of raising many dry land crops as mixed crops; with jola as the main crop 'togare' and a number of other minor crops are raised as mixtures.

Likewise with ragi as the main crop on red soils 'avare', 'togare', fodder jola, etc., are raised as mixtures. These are all dealt with separately under the respective crops. In the case of cotton, the mixed crop of grain is 'navane'. Of this five rows or sometimes three rows alternate with one row of cotton. In the case of late sown cotton this mixture is invariably practised, and if sown a little earlier then the cotton is sown pure or mixed with 'navane'. The latter matures in about three months and immediately after it is harvested, the space occupied by it is ploughed up or worked with a bladed hoe; this operation helps the cotton crop to make vigorous growth. This kind of mixture is adopted only in the case of the indigenous cotton (sannahatti) and not with the New World types. In the case of the 'nadam' cotton (G. obtusifolium), the grain crops 'sajje', jola and the pulse crop horsegram are used for growing as mixed crops.

In some cases the cotton is left over to ratoon in the following year, so that it occupies the ground for two years, instead of one year which is the usual practice. The plants are cut down low before the rains commence and completely new growth started or they are left alone and only new branching encouraged. The interspaces between the rows are ploughed or hoed. There is considerable saving both in time and expense and the crop is able to take advantage of the early rains and give almost a normal yield. It is adopted both by cultivators who own large areas with whom thorough cultivation of all the land may not be possible in time and by the thriftless ones who neglect cultivation In the case of 'nadam' cotton the plants are allowed to stand for three years, jola-cotton-Bengalgram being the rotation. This cotton does not make sufficient growth in the first year to give a crop and is therefore left over for an additional two years; in the second year a normal crop is obtained and in the third year a somewhat smaller crop.

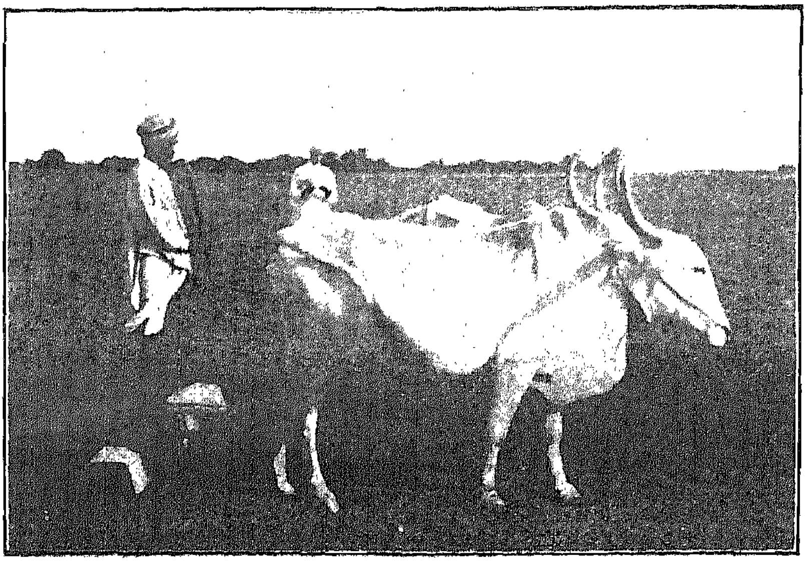
The 'New World' cottons are grown pure, whether they are grown as dry crops or as is more often the case, as irrigated crops. In the former case, if they are grown on red soils, they follow a crop of ragi, usually of the early type called 'kar' ragi. In the case of this early ragi, it is possible to plough the field after it is harvested; it is therefore left in a ploughed condition after harvest and with the early rains of the following year the field is further ploughed and cultivated and sown with this cotton. Elsewhere they follow the main season ragi; on these soils this cotton may be rotated with other crops like castor also. When grown under irrigation they partake of the nature of garden crops and a variety of crops enter into the rotation. Thus in some sections sugarcane, cotton, rice and Bengalgram form the rotation, if the soil is of the heavy type, somewhat like the black cotton soil. In other kinds of soils cotton, rice, or irrigated ragi, and tobacco are grown in rotation. Sugarcane,

jola, turmeric, chillies, groundnuts are other crops, one or other of which can be rotated with cotton and are indeed very well suited for this purpose.

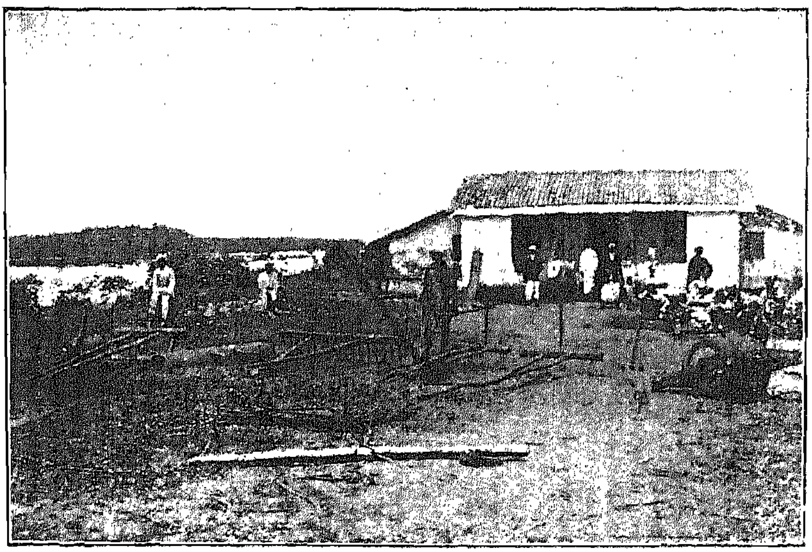
Preparation of the soil.—The preparation of the field for sowing cotton on the black cotton soil and for the subsequent cultural operations is peculiar and presents many interesting features especially in regard to the implements used. Firstly, for instance, the surface of the black cotton soil is generally more or less like a powdery crumbled mass somewhat similar to the condition which a shallow plough or cultivating tool will produce. A light stirring up of the surface is sufficient to produce a moderately good tilth for sowing and such stirring up is easy and rapid with the peculiar implements in use for the purpose. *viz.*, the bladed harrow or hoe called 'dodda kunte'. Secondly, the black cotton soil affords favourable conditions for the growth of deep rooted weeds, the chief among which is the grass, called 'garike' or 'hariali' (Cynodon dactylon) in Kannada. This grass is deemed very harmful to the cotton crop and is at the same time difficult and expensive to get rid of. Deep digging by hand tools or ploughing with specially deep-ploughing heavy ploughs is necessary, and this operation is carried out at intervals of three to six years depending upon the extent to which the weed has spread. Not more than a small extent of ground, often less than an acre, can be managed in any one year if the field has to be dug and the work is therefore carried out in a kind of rotation, over the three or more blocks into which the holding may be divided for this purpose. Even if deep ploughing is resorted to instead of digging, not more than a few acres can be managed and then also the different fields have to be worked in rotation. Thirdly, the black cotton soil becomes very sticky when wet and the digging, ploughing or deep harrowing has to be carried out only when the soil is comparatively dry during the hot weather. This makes the work still more difficult. Fourthly, the farming on the black cotton soils is generally 'extensive'; holdings and fields are much larger than in the red soil tracts and methods and implements are designed to enable the cultivator to work the holding with very much less bullock and manual labour than would be possible on a red soil holding.

Implements.—The tillage implements common in the black cotton soil tracts are (1) country ploughs of a somewhat larger size than are used in the red soil tracts, which require a pair of really large bullocks to work. Improved, *i.e.*, mouldboard ploughs of iron are now taking the place of these wooden ploughs. (2) Very heavy and large wooden ploughs which are used for the special hot weather ploughing for the removal of the 'hariali' grass. Large iron mouldboard ploughs have replaced these in many villages and a large number is now in use throughout the cotton country. The iron ploughs used for this purpose in the earlier years were ploughs with fixed

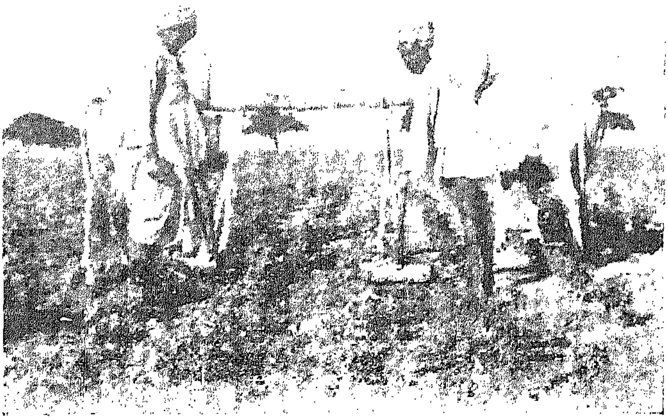
mouldboards, but at present the ploughs are mostly of the turnwrest type, in which the mouldboard is set alternately right and left with every turn of the plough. The heavy ploughs whether of wood or iron are worked with four to six pairs of bullocks and will plough the soil about 9 inches deep or, if the measurement is made from the crown of the clods to the bottom of the furrow, about double this depth. (3) Bladed harrows of various sizes. These bladed harrows called 'Kuntes' in Kannada and 'Guntakas' in Telugu are all made in one general pattern. The body of the implement is a log of wood roughly octagonal in section, with the length varying according to the different sizes, and the working part is a heavy blade of iron about 3 to 4 inches in width and varying in length in the different sizes from 6 feet down to 9 inches. The blade is attached to the body of the implement by means of two stout wooden pegs one at either end so that the arrangement resembles roughly a rectangle with the blade and body forming the two opposite sides. The attachment of the pegs to the body and that of the blade to the pegs is such that when the implement is worked, the pegs and the blade make a very broad angle with the ground almost to the extent of lying flat. The depth of working can be changed by making this angle less broad. When at work the blade moves forward cutting under the clods and soil crust and severing the underground parts of the weeds. The implement is provided with a handle and a pair of yoke poles at the end of which the yoke is tied. In the heavy 'kunte' the body is large and may be about a foot across; in the lighter ones about 6″ across and the still smaller ones about 4″ across. The different 'kuntes' are known by the following names in Mysore :—(*a*) the 'doddakunte' or 'Heggunte', the heaviest type, with blade about 4 inches wide and about 22 or 24 inches long, which is also the width of the ground it works at every journey; (*b*) the 'balu kunte', a much lighter and broader implement, with body about 3 to 4 feet long and a blade about three to four feet long and 3 inches in width. This works a space of about 4 feet in width (there are also types which work up to six feet in width) and serves different purposes such as harrowing, levelling, pulling out weeds, covering seeds, etc. It is much easier working and lighter than the 'doddakunte'; (*c*) the 'yede kuntes'; these are small implements, in which the blade is about 9 inches long and are intended to work between the rows of crops. 'Yede kuntes' with different lengths of blade up to 18″ are made, to suit the different distances at which the rows of different crops may be sown. These are so light that two to four such kuntes are attached to one yoke and pulled by one pair of bullocks, each, however, being in charge one of man; (*d*) the levelling board, which is a heavy log of wood about six to seven feet long, either solid or hollow with a semicircular or trapezoidal section and drawn with the hollow face downwards. This



The 'Koradu' or clod crusher, generally used on the black cotton soils. [Mys. Agri. Dept.



A collection of indigenous tillage implements, largely used in the black cotton soil tracts, of the Mysore State. [Mys. Agri. Dept.



Interculturing cotton, with two hoes hitched to one yoke.
[Photo by Author.

The 'Dodkunte' or the heavy-bladed harrow, very generally used on the black cotton soils. [Mys. Agri. Dept.

is used for crushing clods, levelling and compacting the loose soil both before and after sowing; (e) the seed-drills, with tynes varying from three to five are also used sometimes for light tillage work, such as for light harrowing and stirring of the soil, for making lines or rows for sowing, etc. When the drills are used for such tillage work, the seed bowl and the sowing or seed tubes are both removed.

In the typical black cotton soil tracts such as Chitaldrug and eastern Shimoga, some 25 to 30 acres are farmed with only pair of good bullocks; the equipment by way of implements for a holding 50 or 60 acres in extent will be the following:—One 'doddakunte,' two lighter kuntes or 'balu kuntes,' one heavy plough, two ordinary ploughs, one seed-drill with two tynes, one seed-drill with three tynes, eight 'yede kuntes' (or interculturing kuntes), two specially long yokes for these 'yede kuntes,' one light yoke for the drill, two yokes for the ploughs, one heavy yoke for the 'doddakunte,' one cart for manure and produce and one specially large cart with heavy wheels for carting jola stalks.

Sowing Seasons.—The main season for the sowing of cotton extends from about the middle of July to the end of October. In the regions of early rainfall such as those called 'kar ragi' tracts in Mysore, the sowing season is much earlier and begins from the middle of May. In this season only the 'doddahatti' or Dharwar-American cotton is sown. As the cotton is ready to pick from about four months after sowing, the rains of the year come practically to an end when the cotton is sown in the usual season, *viz.*, from July onwards. Bright sunny weather prevails which is ideal for picking. As the hot weather sets in, the bolls mature and open more rapidly, so that a large number of bolls is ready to pick at the same time, and the expense of carrying out a number of pickings greatly reduced.

In the case of earlier sowings, picking is also early and commences before the rains have quite stopped; the cotton is often spoiled, on account of any rain that may be received at this time, the cotton becomes wet and also splashed over with the black mud from the soil especially the lower bolls.

The earliest cotton to be sown is the Dharwar-American or 'doddahatti', which in the early rain tracts is sown about the middle of May, and in the main season in the month of June to July. The indigenous cotton is sown later, beginning from the first week of August and extending up to the end of September. Irrigated cottons like Cambodia cotton and other New World cottons are sown in the month of October. An innovation has however been started of sowing cotton of the New World types in the month of February and it is claimed that the yield from such sowing is better and that disease does not appear. As the picking season in this case will begin about the month of July, the risk of the opening bolls being spoiled by the heavy S. W. monsoon and of the cotton being blown down

by the high winds is great, and this is especially so in these types, because the cotton is held very loosely in the open bolls and can even be shaken down. There is also the question of insect pests, especially the caterpillars and grasshoppers on the young crop, which are both very severe about the beginning of the rains.

Preparing the Seed Bed.—The field for the sowing of cotton after jola is prepared by first working the '*doddakunte*' on the field; this uproots the jola stubble which is all collected and burnt. After a good shower of rain and the drying of the ground somewhat so that it can take the plough, the field is ploughed with an ordinary plough, either with a country wooden plough or an ordinary sized iron plough. The field is now left in large clods, which are later broken by working the 'doddakunte' once again. The levelling board which is also somewhat of a clod crusher is worked next; this pulverises the soil further. Cattle manure is now spread but the practice of manuring cotton is not common; the manure is usually applied to the preceding crop of jola. It is however desirable that cotton should be manured and especially so when the mixed grain crop 'navane' is grown along with it. The irrigated cottons are however heavily manured as in the case of garden crops. The manure applied to dry land cotton is about five cartloads of cattle manure per acre. After the manure is spread the light kunte called 'balukunte' is worked, which harrows the field and mixes the manure with the soil. The field is now ready for sowing. The seed rate for the indigenous cotton is 10 lbs. an acre when it is sown pure and about 7 lbs. an acre when it is sown with a mixed crop 'navane.' The 'doddahatti' is always sown pure and at the rate of 7 lbs. an acre.

Treatment of Seed for Sowing.—Cotton seed has to be prepared for sowing by some kind of treatment which will make the individual seeds run free and loose, and not cling together as they do if they are not so treated. On account of the fuzz on them, the untreated seeds adhere together and sowing becomes difficult. The local cotton 'sannahatti' has much less fuzz on it than Dharwar-American and Cambodia but all have to be treated nevertheless. The treatment consists in rubbing up the seeds with a paste made up of moist earth and cowdung, when the fuzz on each individual seed becomes pasted on to the seed itself and the seeds no longer cling together; with a little drying in the shade the seed is ready for sowing. This simple method is found quite efficient. In foreign countries and in large scale farming, the seed is treated with a paste made of maize or rice starch, and is put into a large barrel or drum along with the paste and rotated like a butter churn. The fuzz on the seed becomes pasted over to the seed in the same way as in the other method, bringing the seed into a fit condition for sowing. Instead of this mechanical method, chemical methods are also

recommended which have the effect of dissolving or burning off the fuzz, without detriment however to the germinating capacity of the seed. The chemicals used are strong sulphuric acid which chars or burns the fuzz and chloride of zinc which dissolves the fuzz. Commercial strong sulphuric acid is used and the seeds are treated for two minutes in the acid, removed and then washed free of acid. In the case of the chloride of zinc, the seeds have to remain immersed for ten to fifteen minutes in the solution; it has been found that the treatment not only removes the fuzz but also improves the germinating capacity of the seed and that plants from treated seed grow more vigorously than those from untreated seeds.

Quickness of germination is greatly to be desired and a soaking of the seed in water over night prior to the ordinary treatment with cowdung paste hastens the germination; varieties which sometimes fail to germinate if sown dry will germinate with great ease after this preliminary soaking. The maximum amount of soaking is 36 hours, beyond which soaking reduces the germination. A soaking for 24 hours should be enough to give satisfactory results. The Dharwar-American and Cambodia cottons do not succeed on black cotton soils as they do on red soils in South India, the difficulty being in getting them well established quickly. With quick germination and with conditions favourable to rapid growth in the earlier stages, the crop however is found to do well. In order to afford favourable soil conditions for such a result it has been suggested that the seed should be dibbled in holes filled with sand and that the sowing should be on ridges rather than in furrows or in the flat; the suggestions however do not seem to have been tried to any extent.

Sowing Methods.—The sowing of cotton is done in more ways than one, but whatever implement or sowing distance is adopted, sowing in lines is the general practice in Mysore. It is only in parts of the Tamil districts of South India that the practice of sowing cotton broadcast and ploughing the field for covering the seed prevails. The field having been prepared as already described, cotton is sown by means of seed drills which have tynes about two feet apart in the case of cotton which is sown pure. The seed is sown either in a regular drill sowing two rows at a time or through the one line drill called 'sadde,'; one such 'sadde' is tied behind each of the two tynes of a two-tyned drill, the tubes and the seed bowl from which have been removed and which serves merely as furrow opener. When the cotton is sown as a mixed crop with 'navane', a seed drill with tynes placed about 9 inches apart and sowing either three or five rows is employed and after every three or five rows of 'navane' are sown one row of cotton is sown through a 'sadde'. The cotton rows in the former case, *i.e.*, when sown pure are two feet apart and in the latter case, *i.e.*, when sown as a mixed crop are either 3 feet apart or 4½ to 5 feet apart. In the rows themselves the seeds

fall at irregular distances from 3″ to 9″ on the average. In the case of 'doddahatti' (Dharwar-American) which is always sown pure, a wider spacing is given both between the rows and in the rows themselves. The seed-drill used has two tynes set about 2½ feet apart and the seeds are dropped at distances of 9 to 12 inches on the average. It is also customary in certain places to use the seed-drill merely as a furrow opener, once along the field and once across; by this means the field is laid into furrows drawn chess-board fashion. The seed is then dibbled by hand at the intersections of the furrows at the rate of two or three in each hole. After the seed is sown the light wooden kunte (balukunte) is drawn over the field covering the seeds. If soils are not of the heavy black cotton soil type, a plough may follow the seed-drill ploughing a shallow furrow alongside of each furrow sown, an operation which not only covers the seed but also helps more moisture to collect round the germinating seed.

In regard to the distance of planting where cotton is grown by itself and not with a mixed crop, the variety sown, the nature of the rainfall, the fertility of the soil, manuring and the nature of cultivation whether as a dry crop or as an irrigated crop are all factors which have a bearing. The indigenous cottons have a tall growing habit, the branches spring very close to the main stem making a narrow angle with it; the American cottons have a broader growing habit and the branching is almost horizontal. The latter have therefore to be sown at wider distances than the local varieties; and in case, furthermore, they are grown under irrigation and well manured they have to be given a wider spacing both in the rows and between the rows than when they are grown as dry crops. In the case of the local varieties also which are all grown as dry crops, a wider spacing will be an advantage where the rainfall is higher, and the soils richer, than under the opposite conditions. In the case of the American cottons it is reckoned that when planted at a distance of 3 feet both ways, an yield of one boll per plant will amount to a maund of 25 lbs. per acre. Under irrigation some thirty to fifty bolls per plant can be counted on the average, with good specimens going up to even one hundred. This distance of 3′ by 3′ may be taken as the standard which may be slightly increased or reduced according to nature of the soil, manuring, etc.

The local 'sannahatti' is grown very close in the tracts of poor rainfall, the rows being 18″ apart and the plants about 3 to 4 inches apart on the average in the rows. The rainfall conditions are such that the plants make very little growth and the yield per plant is so small that close sowing and a larger number of plants will have to make up for this drawback. In the tracts of moderate rainfall the distance given is two feet between the rows and the same three or four inches in the rows, which should be considered a satisfactory spacing as far as the rows are concerned, but certainly too close in the rows. A spacing of at least

six inches will have to be maintained, by a certain amount of thinning out if not by a more regulated dropping of the seeds at the sowing time itself.

After-Cultivation.—After the plants come up, the only operation is the working of interculturing tools, the 'yedekuntes,' systematically. This is carried out repeatedly, until the rows close up, which may mean three times during the period. When the crop is sown chess-board fashion, the interculturing 'kunte' is worked both lengthwise and breadthwise in the inter-spaces between the rows. In the case of the irrigated cotton the field will have to be laid out into sections suitable for furrow or bed irrigation. Weeding by bullock implements will not be possible to the same extent. Thorough weeding is however very necessary and considerable hand weeding will therefore have to be done for the irrigated crop. In the case of the Dharwar-American (doddahatti) and Cambodia cotton, it may be advisable to top the plants at a height of about three feet, in order to induce longer and heavier branching.

Yields—The 'doddahatti' crop begins to flower in about 45 days and the first bolls begin to burst in about three months after sowing. The plants however continue to flower and fruit and the bulk of the harvest may come off in the fourth month and the last pickings may not finish until about five months are over. If the plants are kept on and if there is moisture in the soil or the field is irrigated, there will be a second flush which will go on till the seventh or eighth month. Picking has to be done at frequent intervals as and when the bolls open; the cotton is held loosely in the capsule and may be blown down by the wind and become spoiled if it is not picked quickly.

The 'sannahatti' crop sown in September becomes ready for the first picking in January following and the picking may continue till March. Usually in three pickings or four at the most, the whole crop is gathered. This cotton is held rather firmly in the open bolls and will therefore admit of being left on for sometime until, for example, a large enough proportion can be picked at one time. The Doddahatti and Cambodia and other American types give comparatively clean cotton, but the local cotton is likely to be mixed up with much leaf and broken bits of the boll. Further on account of the attack of the boll weevil, this cotton is likely to be much stained and mixed with small and shrunken locks of cotton. It will be advisable to pick good cotton separately from such damaged and dirty cotton.

The yield of seed cotton from the local cottons in Mysore will average about 250 lbs. per acre. Under good cultivation and in first class black cotton soil in a year of good rainfall quite double this yield is obtained. The average yield of 'doddahatti' grown as a dry crop is about 350 to 450 lbs. of seed cotton per acre; good crops from fields which have not suffered from the red leaf disease may go up to 600 lbs. per acre. The irrigated American

cottons like Cambodia and the various crosses give, provided they do not suffer from the red leaf disease, heavy yields up to 1000 lbs. per acre and if left over for a second flush may give an additional 250 to 400 lbs.

Disposal of cotton plants.—The disposal of the cotton plants after the cotton crop has all been picked generally consists in leaving them on the field until the time comes for preparing the ground for the next following crop. The plants furnish considerable grazing during this period for both cattle and sheep and it is usual to make such grazing a consideration for the penning of sheep. The plants are later pulled out completely by working the heavy 'kunte' on the land, the end of the 'kunte' near to the cotton row being pressed down so as to make it work deeper and uproot the cotton plants, which are pulled out by the hand at the same time. As part of the scheme for the control of the stem borer, which requires that the plants should be pulled out after the picking season is over, a small pulling instrument worked by hand is being used and popularised in some parts of India. The cotton plants after removal from the field are dried and used only as fuel or are burnt on the field itself. As the black cotton soil tracts are vast treeless plains fully under cultivation, there is always much difficulty for fuel in all villages in these regions and the dry cotton plants meet this difficulty to some extent. The conversion of the material into compost for use as manure is a good alternative and can be adopted with all the surplus available. For this purpose the stalks have be crushed and broken in a stone mortar mill, under the stone threshing roller or under the feet of bullocks, preliminary to being put in the compost heap. If the material is not prepared in this way. the decay is very slow and the handling too becomes difficult.

Botany and Varieties.—The cotton plant belongs to the natural order Malvaceæ and the genus Gossypium. The genus comprises many species, of which a good number is represented by the different kinds of cotton grown in India. The cotton plant is a shrub with branches ascending or spreading and both stems, branches and leaves are quite green in colour or flushed with dark red and covered over with short hairs. The leaves are usually lobed and palmate with prominent stipules. The inflorescence is a one-flowered cyme with a short peduncle and well-developed bracteoles. The calyx is gamosepalous and the corolla is five petalled, deep red, white or yellow in colour, with or without a black centre or 'eye'. The anthers are borne on tubular stamens and the ovary is three to five celled, corresponding to the same number of locules in the bolls; the seeds are hard coated, naked or covered with 'down' or 'fuzz'.

The various Indian and other cottons belong to the different species noted below:—

G. obtusifolium, which is represented by the varieties called 'nadam' and 'uppam'.

✓ G. herbaceum, which is represented by the varieties called Broach, Wagad (Dholleras) Javari, Tellapathi, (northerns and westerns), Sannahatti of Mysore, Kumpta, Goghari.

G. indicum, represented by the varieties called Karunganni (of Koilpatti) Nandyal (northern), Gaorani (Hyderabad, Deccan), Bani (oomras), Mollisoni (Bengal and the Panjaub) and the Yerrapathi (of Cocanada).

G. neglectum, represented by the varieties called Verum (C. P. and Berars), Jarilla (Khandesh and Nasik), Sindh N. R. (of Middle Sindh) Rosea.

✓ G. arboreum, represented by the dark purple flowered Deokappas.

✓ G. hirsutum, represented by the various American cottons in India such as Dharwar-American, Gadag, Panjab American, Sindh-American or Sudhar, Cambodia, Doddahatti (Mysore).

G. maritimum, represented by the Egyptian cottons.

G. Peuvianum, represented by the perennial cottons called Kidney, Brazilian, Caravonica.

G. barbadense, represented by the famous Sea-Island cotton.

G. cernuum, represented by the Comilla cotton.

In South India, the cotton is also known by various trade names such as Cocanada, Westerns, Northerns, Tinnies, Salems, etc. These are not cottons belonging to any one single species but are mixtures of several. Thus, the Cocanadas contain G. obtusifolium and G. indicum (Yarrapathi), the Westerns and Northerns contain G. herbaceum and G. indicum, the Tinnies contain G. obtusifolium and G. indicum and the Salems mostly Cambodias grown in that district.

The varieties grown in India may be classified broadly as the Asiatic and the local varieties and the American or New World cottons. Their charateristics are markedly different in many important respects. The Indian cottons are distinguished by their green stems, light green leaves, upright and somewhat narrow habit of growth, with branches springing at a very narrow angle with the main stem; the flowers are generally deep or canary yellow in colour with an eye or large black dot deep inside the flower at the base of the petals. When the petals begin to wilt after the flower is fertilised and closes, they retain their yellow colour. The bolls are comparatively small, are green in colour till they begin to dry and split and are made up of three to five locks or sections; when the bolls split and are ready to pick the seed cotton is held somewhat firmly—at any rate much more so than in the American cottons. In one variety, indeed, (Wagad) the locks do not open fully at all and the cotton is held so firmly that the bolls have to be beaten for separating the cotton from the capsules. The cotton is generally white and some are brilliantly white; in certain varieties the colour varies from dull white to almost 'khaki'. The cotton is mostly short in 'staple' or length of fibre, in fact the whole of these cottons are classified as 'short-staple'. In some the staple is very short, in others medium. The staple is also in most

varieties coarse, in some indeed very rough, in others it is quite soft and silky. The percentage of lint to seed cotton called the ginning percentage varies a great deal but in the varieties largely under cultivation it is medium to good, varying between 25 and 30 per cent. There is one variety however which gives up to 50 per cent and at the other extreme is a curiosity such as the wild cotton which has practically no lint at all. The seeds can be easily ginned, the lint parting from the seed with a very light pull. After ginning, the seeds have only a very thin coat of lint and are said to be smooth or non-fuzzy in contradistinction with American cottons which are all fuzzy. The seeds are usually small and rounded, as compared with the latter. There are some minor exceptions in which the seeds are naked, *i.e.*, have no lint left on them at all after ginning, and look smooth and black like an ordinary black bean seed. They are all bushes grown as annuals with the exceptions noted under 'rotations', which are left to ratoon for two or three years The bark of the stem in this case becomes greyish white in colour and somewhat rough, though the stem continues to be pithy in the centre and brittle. Some indigenous varieties are somewhat different from the above general description. The variety called G. arboreum is grown as a perennial, it has deep red flowers possessing a dark eye or spot inside at the base of the petals, the stem and leaves have a dark appearance flushed with the deep red tint of the flower. The cotton is white, fine and silky, the staple medium and the seed non-*fuzzy* and the thin coat of lint is green in colour. The variety called G. roseum has white flowers and the variety G. indicum has a reddish tinge in both stems and leaves.

The American and non-Asiatic cottons were first introduced into India by the East India Company in their efforts to grow American cotton within their own dominions and so to become independent of supplies from America. Many varieties of Upland and other types of cotton, such as the Peruvian types, were imported and even foreign experts were brought over to supervise the cultivation and train local agriculturists. The cultivation which was mostly confined to Madras and Southern Maharashtra was a failure and could not displace the local cottons. There was however one notable survival, now represented by the Dharwar-American, which has become a well established American Upland cotton acclimatised in India and grown largely both as a dry crop and under irrigation. Stray specimens of the Peruvian cottons have also survived. The cotton called Cambodia, also an Upland type which was introduced about 40 years ago and taken up as an irrigated garden crop has met with remarkable success and become a very popular variety. Sea Island and Egyptian cottons are comparatively recent introductions especially for the canal irrigated tracts of Sindh and the Punjaub and very lately in Mysore as part of the efforts made to

grow long staple cotton in India itself, to meet the needs of the Indian mills requiring finer counts of yarn.

The American Upland cottons differ markedly from the indigenous cottons in their appearance and habit of growth; their stems and branches have a reddish colour and the leaves are tinged red, the leaves are broader, the branches spring horizontally from the stem and the plants therefore cover several feet in circumference. The root system is not very deep, the tap root does not go as deep as in the local cottons but the lateral roots have a wide spread, extending almost horizontally outwards. The flowers are larger, are cream coloured when they open and become red when they close; they do not possess the eye or dot at the base of the petals inside the flower, the bolls are very much larger and rounded or longish, the cotton is brilliant white, is held in three to five locks from which it parts with great ease. The cotton fibres are however held more firmly and the ginning is not so easy as in the case of the local cottons. The seeds are larger, somewhat conical in shape and markedly 'fuzzy'. The lint is of the soft long stapled type generally and the ginning percentage is higher than in many local varieties. The yields are also much higher. The crop is however subject to a serious red leaf disease in which the leaves become red throughout or in patches of the surface leading to a shedding of the leaves, buds and bolls and if the plants are young to the drying up of the young plants themselves. No satisfactory remedies are known and it is held by some that these non-Asiatic cottons are not suited to India at all.

Quality in Cotton.—1. Staple length. The quality of any particular cotton depends upon its length of staple, fineness, feel, such as rough or smooth and silky, strength and its bright white colour. The cotton on the seed is composedof fibres, all of which are not of one uniform length but which are of varying lengths. The large bulk of them are however of one particular length varying within very small limits while among the remainder some are very much longer and some very much shorter than this length. This predominant length called mean length is taken as the length of staple of the particular cotton. For example in a cotton the mean length of whose fibre or staple is 0·7 inch, the distribution was as below:—

Length in eighths of an inch	Percentage	Length in eighths of an inch	Percentage
2	0·3	7	44·0
3	1·3	8	15·2
4	2·5	9	3·4
5	8·5	10	0·8
6	24·0		

The higher the staple length the more suited is the cotton for spinning the finer yarns or higher 'counts'. Most Indian cottons do not spin above 20 counts and many can be used only for counts below 10. The number of windings on a special frame which a specified weight of the yarn will give is reckoned in counts, so that the higher the count the longer is the length of the yarn for the specified weight and therefore the finer is the yarn. The staple lengths of different types of cotton are as below :—Cottons with a staple below ·75 in. are classed as short staple cottons, those with a staple length between ·75 and 1·25 in. are classed as medium or medium long, and those above 1·25 in. are classed as long staple cottons. The counts of yarn for which the abovementioned classes can be used are generally taken as under :—Short staple-below 30 counts; medium and medium long staple—up to 50 counts; long staple—all counts above 50. The short staple cottons find considerable use for mixing with wool and on this account sometimes fetch a higher price than will be warranted by their length of staple.

2. *Fineness.*—The fineness of the fibre is closely related to the staple and is an expression of the weight per unit length of the fibre. The finer the fibre the finer is the yarn spun and the better it is. The fineness may often arise at the expense of the strength of the fibre which is one of the important requirements of good cotton The fineness is a character which is somewhat influenced by the composition of the soil on which the cotton is grown, and by seasonal variations, so that a variety which ordinarily yields a fine fibre may become less so when grown on a different soil and in a different season. The fineness of fibre as expressed by the weight per unit length in some of the different varieties varies between wide limits as may be seen from the following examples :—

Variety	*Fibre weight per inch (in 10^{-6} oz.)*
Verum	·170 to ·191
Karunganni	·147 to ·186
Cambodia	·122 to ·150
Jayawant	·140 to ·197
Panjaub-American 289F ...	·075 to ·152

Moreover it is possible by skilful hand spinning to spin very high counts with only medium staple cotton; the famous 'Dacca muslins' for which yarns were spun so fine that a pound of yarn measured 250 miles in length were the products of only medium staple cotton which are said to have been spun by hand spinners according to a technique not well understood at the present time.

3. *Strength.*—The strength of the cotton fibre is an important factor in valuing a cotton. The strength is tested usually for the yarn of a particular count (generally 19 or 20)

spun out of the particular cotton and is given as the number of pounds which this yarn will stand without breaking in the apparatus used for this test. In any particular cotton an increase by selection in the staple is sometimes accompanied by a loss of strength which has to be guarded against. Seasonal conditions moreover may bring about changes in this character, sufficient to mask improvements due to selection. An approximate figure of from 75 to 80 pounds for 20's yarn may be taken as the lower strength limit expected; in very strong specimens this figure may go up to even 115 lbs. As regards individual fibres, the average breaking strength of the fibre for American varieties is given as 6·83 grms. with a variation ranging between 4 and 14 grms. as extremes. In proportion to the size of the fibre, cotton is three times as strong as wool.

4. *Feel.*—The feel of cotton, *i.e.*, whether it is soft and silky or coarse and rough to the touch, is also obviously an important character, as the former will lead to smoothness and fineness in the yarn and consequently of the fabric and the latter give the contrary effect. Varieties differ from each other greatly in this respect, some being strikingly soft while others are very rough and coarse not unlike a fine grade of sand paper in feel.

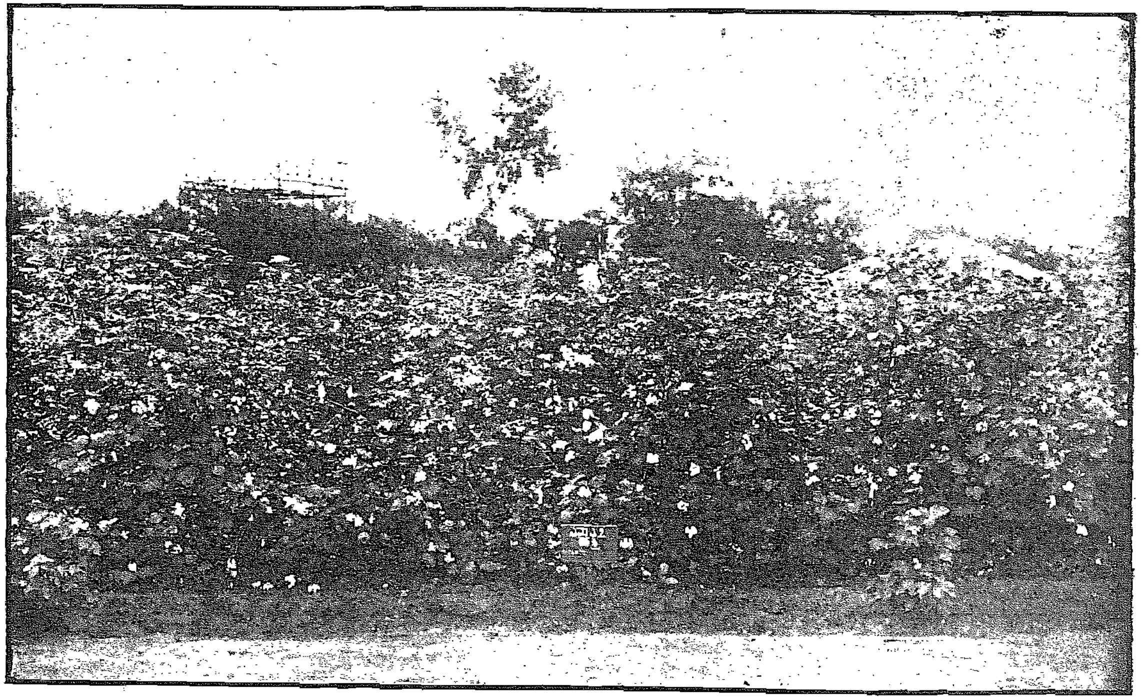
5. *Colour.*—A bright white colour is a point much in favour of any type of cotton and goes to enhance its price, other things being equal.

Ginning percentage.—Seed cotton or 'Kappas' is frequently judged by its ginning percentage especially in the evolving of new and improved types principally by selection. The ginning percentage is the figure showing the proportion of the lint by weight in 100 parts of seed cotton. Apart from the fact that it is for the sake of the fibre or lint that the world's cotton crop is grown, the ginning percentage assumes great importance in India, principally because the growers' cotton in India is sold in the primary markets as seed cotton and as such it naturally fetches a price high or low according as its ginning percentage is high or low. A 'kappas' with a high ginning percentage always fetches a substantial premium as the buyer of such 'kappas' will obtain a larger amount of lint therefrom. Once however the cotton is ginned then it is judged on quite other considerations such as those described above. The ginning percentage is also taken as an index of the yield of cotton per acre, as the larger the lint per pound of seed cotton the larger the yield of lint per acre. But it is obvious that the lint per acre is the resultant of several factors, out of which the ginning percentage can be only one. It may be and often is offset, for example, by a reduction in the number of bolls per plant, or by the actual amount of seed cotton in the boll. The larger the seed the greater is the quantity of cotton fibre on it, though in view of the heavier weight of the seed the ginning percentage may be low; while in the case of

the smaller seeds the actual amount of the cotton fibre on the seed is less on account of the smaller surface area of the seed, but the ginning percentage may be higher. Nevertheless, the ginning percentage continues to be considered an important attribute of any particular variety. The following table shows the range of the ginning percentage for some of the different kinds of cotton which were grown under similar conditions on the Babboor Farm, Mysore:—

Variety	*Ginning percentage.*
Garo Hill	48·0
Bokda (neglectum)	38·0
Cernum	36·0
Lone Star (American Upland) ...	34·3
Karunganni (indicum) ...	32·3
Sea Island	31·3
Egyptian (Ashmouni) ..	31·2
Sannahatti (herbaceum) ...	26·5
Nadam (obtusifolium) ...	*21·5*

Cotton varieties in Mysore.—The cottons of the Mysore State comprise mainly two kinds, *viz.*, the 'sannahatti' (G. herbaceum) and 'Doddahatti' (the Dharwar-American. G. hirsutum). The name 'sannahatti' is also applied to the cotton called 'nadam' in Coimbatore, which is G. obtusifolium and which is the cotton grown in the black cotton soils of the Mysore district. The sannahatti' in the eastern taluks of the Chitaldrug district, though largely consisting of G. herbaceum, contains a large admixture of a closely similar cotton, with the difference that the seeds are smooth and free from any fuzz altogether, in contrast with the bulk of the 'sannahatti' which has a thin coat of fuzz on its seed. The 'doddahatti' also consists of two types, one having a white fuzz on its seed and the other having a slightly green fuzz; both are grown mixed together, and appear identical in all other respects. To a small extent is also grown another cotton called locally, Bokda cotton, which is G. neglectum and which gives a high ginning percentage of white rough cotton with a short staple. All the cottons have a good white colour but differ in the ginning percentage and in the length and quality of the staple. Thus 'sannahatti' (G. herbaceum) with white fuzzy seed gives a ginning percentage of 25 on the average (variations exist from 20 to 28) with a staple of about ¾ inch, in which character also much variation exists. The 'sannahatti' called 'nadam' (G. obtusifolium) gives a ginning percentage of only about 21 but has a slightly longer staple. The naked—seeded 'sannahatti' has a ginning percentage of 20 to 25 with a fairly strong staple between ¾ and ⅞ inch. The 'bokda' is a white rough cotton with a very short staple but has a ginning percentage of 34 to 35 per cent. The 'doddahatti' types have a ginning



Field of M. A. II Cotton cultivated as a dry crop, Closepet, Mysore State. [Mys. Agri. Dept.

percentage of about 28 to 32 with a strong white staple with a length between $\frac{7}{8}$ and 1 inch.

A great amount of work on the improvement of these cottons both by selection and by cross-breeding has been carried out and the abovementioned older types are being largely and gradually replaced by the newly evolved types. Among the latter are (1) 'selection 69' which has been evolved by selection from the local sannahatti (fuzzy—seeded G. herbaceum), which gives a higher ginning percentage, a better yield and is fairly wilt resistant. (2) H. 190, which is a cross between 'selection 69' and the red-flowered G. arboreum, which gives a high ginning percentage of 30 and a better lint. It is intended to replace the 'sannahatti' from the seeds of which this can be distinguished by the green colour of its fuzz. (3) Cernum—Nadam crosses (C.N. 45, C.N. 86, etc.) which are crosses between the Cernum cottons possessing the high ginning percentage of the Cernum and the lint length and fineness of Nadam. These are intended to replace the local 'Bokda,' which is very rough and short stapled, but has a high ginning percentage and whose cultivation though undesirable is being continued on account of this special advantage of a high ginning percentage.

The 'doddahatti' (Dharwar-American) is also being replaced by two newly evolved types *viz.*, M.A. II and M.A. IV. These have been produced by crossing the local 'doddahatti' with a perennial cotton of the type G. Peruvianum. These cottons give a higher yield, with a very white and fine staple, for which they have gained a name. The M.A. II is also fairly resistant to the 'red leaf' disease. In addition to these, in the irrigated tract under the Irwin Canal several crosses between American types like the Cambodia with the M.A. types of Mysore and the African cotton Uganda such as M.A. V, Co 2 × Uganda, M.A. VI., Uganda × Co 2 and so on have been evolved and are under cultivation. The ginning percentage in these crosses goes up to 34 to 36, and the staple length to 1 inch to $1\frac{3}{16}$ inch. In the same tract even Egyptian and Sea Island Cottons have been successfully cultivated recently.

Pests and Diseases.—By far the most serious pest of cotton, which attacks both local and American cotton and which is present in the crop every year is the boll worm. The worm attacks the young seeds in the bolls, and prevents them from developing, with the result that the cotton yield is reduced to that extent. Sometimes one and sometimes many of the seeds, sometimes the seeds in one lock and sometimes the seeds in more than one lock are attacked, arresting the development of the lock or locks concerned. Not only is the yield of cotton reduced to that extent but such cotton as is obtained is found stained yellow and poor in quality; its mixture with good cotton reduces materially the price which the latter may otherwise fetch. The reduction in the yield is however the more serious loss, which may in bad

cases amount from a third to a half of the expected crop. Hardly a boll can be seen which is absolutely free from the attack in every lock, and as the number of locks is from three to five in a boll, the loss may readily be reckoned. Though the indigenous varieties are otherwise hardy and remarkably healthy as compared with the American types, they are badly subject to this attack and are, if anything attacked to a larger extent. The boll worms concerned in the attack comprise two main kinds, *viz.*, 1. The pink boll worm—*Platyedra gossypiella S.* and 2. The spotted boll worm, of which also there are two kinds, *Earias fabia, S. and Earias insulana, B.* The latter worms not only attack the bolls but bore into the stems as well, especially in the case of young plants. Both classes of worms finish their life cycle within a month, so that both the earlier bolls as well as the later formed ones are subject to attack. There are no remedies, which can be called satisfactory. In the case of the spotted boll worms, one precaution is to avoid plants of the Malvaceous order being grown in the cotton field, as the worms breed on such plants also. In regard to the pink worm it is found that some among the adults are attracted by lights, and light traps therefore will afford some relief. For large scale cultivation, however, neither is of any practical value. Very material relief can be secured if all the seed intended for sowing is well cleaned and then thoroughly dried in the sun and stored in insect-proof bins; it is claimed that the pest is greatly reduced in the crop raised from such seed.

A pest of even greater importance as far as the American types are concerned is the stem borer,—*Pempheres affinis, F.* Attacks by this borer are to be found both in the young and in the fully grown plants and both branches and whole plants may succumb and break off or die; but before this stage is reached growth is much arrested and the normal production of flowers and bolls very much reduced. Attacked plants always show characteristic swellings on the stem near the base of the plant but by this time the pest has done much damage. The pest is so bad that it acts as a serious check on the extension of the cultivation of Cambodia Cotton. The pest lives from year to year in the cotton crop itself and if the plants are left to ratoon or allowed to remain on the field for any other reason, then circumstances favour the perpetuation of the pest. Despite much research, no satisfactory remedy is known, except that of removing the cotton plants from the field promptly after the picking is finished and burning them, with the object of preventing it in the crop of subsequent years. This is one of the few pests in which legislation has been invoked; the Pest Act in Madras compels growers to carry out the removal and burning of the plants within a specified time. It however happens that the pest has several other host plants in addition, a fact which somewhat reduces the efficacy of the above method. Parasitic insects of

different kinds, at least five in number, have been found to prey upon the pest but do not appear to be an effective check. Some success has been attained in the production of resistant types and progress in combating the pest may lie only along these lines.

Aphids, thrips and jassids are other insect pests which frequently cause serious damage, attacking young flowers, buds and bolls, sucking the sap from the peduncles and causing wholesale shedding of buds and bolls. When plants are well grown and luxuriant with the prospect of a big yield, such shedding of buds and bolls takes place with disastrous results. Generally a reddening of the leaves and their shedding also occur at the same time and the ground at the base of the plants is stained black by the oily exudation. The pest is confined to the American cottons, and is probably connected with the problem of the 'red leaf' disease of the cottons. The only remedy which has met with some success is the application of sulphur dust on to the plants with a suitable dusting appliance. More than one application is necessary. Spraying with tobacco decoction or other insecticides, if done thoroughly, also affords relief, but the cost of the spraying will generally make it not practicable.

Bugs, especially the dusky bug—*Oxycarœnus lœtus, K.*—cause material damage to the cotton boll both by arresting the development of the bolls and by staining the cotton. Both local and American cottons are subject to the pest. No suitable remedies have been worked out, though in the early stages hand picking may be resorted to with some success.

There are also several scale insects, which attack cotton; the non-Asiatic cottons are peculiarly subject to these attacks, which sometimes result in the killing out of the plants altogether. Those which, like the Peruvian cotton, the Caravonica cotton, etc., are grown as perennials are usually infested with these insects and either remain in an unthrifty condition or die out altogether.

Diseases.—Among the fungus disease of cotton, as regards the indigenous cotton, the most serious is the cotton 'wilt'—*Fusarium vasinfectum.* The disease is seen in its more serious form in fully grown plants, when the whole plant dries up from top to bottom. In bad cases the field is full of these patches of dying and dried up plants but ordinarily they are seen singly here and there. The 'sannahatti' (G. herbaceum) of Mysore and the Southern Mahratta country (called Kumpta) is extremely susceptible to the wilt and it is unfortunate also that some of the superior selections are more liable to the attack than other strains.

Soil temperature has been found to affect the incidence of the disease very greatly. The optimum temperature for the development of the fungus has been found to be 77° F. and the maximum to be between 95° and 104° which indicates that in the hot weather months of March and April when the soil temperature on the black cotton soils is considerably

higher than this maximum the fungus cannot develop and the plants which have escaped infection in the earlier stages or were infected only late in the season escape the damage. No practical remedies have however been found and work has been done with the object of evolving wilt resisting strains. The technique of testing these new strains claimed to be wilt-resistant has been improved and the new tests are under rigorous conditions, so that the strains which emerge successfully out of these tests should be quite resistant. One such strain, the Jayawant of Dharwar, is much more resistant than the ordinary types from which it has been evolved.

The cotton crop, especially the American types grown under irrigation, is subject to many 'root-rots' which are responsible for considerable annual losses in some tracts notably in Sindh and in the Panjaub. These rots are caused by more than one species of '*rhizoctonia*' and are found to be favoured by excessive moisture conditions in the soil. Lighter and less frequent irrigations coupled with adequate drainage are indicated as controlling factors. It was found in the course of studies of this fungus that hydrocyanic acid gas pumped down to 18 inches below the soil was able to kill the resting spores of the fungus. Commercial cyanide of potash crystals can be introduced into little holes in the soil made by a thin iron rod and covered up, so that the hydrocyanic acid generated in the moist soil may permeate the infected soil. The practical aspects of the method have however not been worked out.

The most baffling disease of the American types of cotton in India is what is known as the 'red leaf disease'. The reddening of the leaves is followed by their shedding and this is often accompanied by the shedding of flower buds, flowers and young bolls. The disease appears whether the crop is grown on the black soil or on the red soil, and whether as a dry crop or as an irrigated crop. Plants are attacked in all stages from young seedlings up to fully grown bearing bushes. In many cases it may be said that the first crop is entirely lost and only the second flush gives a crop. The loss in the aggregate must be very large and this disease may be said to be the most difficult problem and serious obstacle in regard to the cultivation of American cotton in India. Many causes have been considered likely and it is not yet known whether it is a bacterial, fungoid, or virus disease or due to deficiencies or inequalities in the manurial or other ingredients in the soil, moisture conditions in the soil, seasonal effect or favoured by insect vectors or is a physiological effect brought about by a combination of causes. The belief among cultivators is that the disease does not appear in a bad form if the crop is sown very early in the season. There is probably something in this belief as certain experiments indicate considerable variation in the incidence of the disease in crops sown at different periods. From a practical point of view, if it should

prove that sowings in particular months result in a reduction in the incidence of the disease then the sowing time may be altered accordingly at least under irrigated cultivation, where sowings can be made independent of the weather.

Alkalinity of the soil and the rise of underground water too near to the roots also bring about the same symptoms of leaf reddening and the shedding of bolls and buds. Deflocculation of the soil by continuous watering also produces the same result. The reddening of the leaves also occurs as the result of a deficiency of potash in the soil, but no Indian soils are so deficient in potash as to cause the disease. Pot culture experiments moreover using varying doses of potash have not given any definite indication that the reddening can be reduced or controlled by potash manuring.

The presence of jassid flies has also been considered as a likely cause; many crops suffering from the boll and bud shedding and the reddening of leaves are usually found badly infested with these flies. Whether the shedding was due to the draining of the plant sap from the bearing branches or to any specific disease spread by the jassid cannot be stated; but the jassid is probably one of the agencies which can bring about these disease conditions, because checking the jassid attack by the use of sulphur dust as already explained results at the same time in reducing the red leaf disease. This method of control through sulphur dusting to check the jassid attack cannot obviously control the disease where it is due to other agencies.

It was also claimed that some particular organism could be made out in the sap of the diseased plants and that the disease was probably due to a disturbance in the nutrition of the plants consequent on the presence of the organism. Reddening appears however to be produced even when the organism is not present, which casts doubt upon the organism being the causal agent. Anyhow from the point of view of controlling the disease, the finding is not helpful.

The sannahatti (G. herbaceum) is also subject to a disease in which the leaves become much reduced in size and the growth of the plant, especially the branching, is much arrested. It is not however serious so far.

Although in India the above noted diseases are only the major diseases of cotton, in many other parts of the world and to a small extent even in India cotton is attacked by other diseases as well, such as mildews, leaf spot (*Cercospora gossypina*), anthracnose (*Glomerella gossypii*) and several species of *Rhizoctonia*. The last which generally attacks only young plants is also capable of bringing about the death of older plants. All these diseases are regarded as due more or less to soil conditions, such as alkalinity or more often excessive moisture in the soil, all of which predispose the crop to one or other of these diseases.

Chemical composition and uses.—The cotton fibre is a single cell of almost pure cellulose which in this elongated form is an adaptation in nature designed no doubt to help in the dispersal of the seed. The fibre has a slight natural twist and possesses a somewhat oily surface which prevents it from absorbing moisture or taking up dyes. Treatment with alkalies removes the oiliness and then the cotton becomes absorbent. The treatment with alkalies also shortens and swells the fibre, which when stretched to the original length assumes a silky or glossy surface; on this property of the fibre is based the process of 'mercerising.' The mercerised cotton goods possess a silky gloss and smoothness, which untreated cotton goods do not. Cotton is acted upon by strong nitric acid and is turned into nitro-cellulose or 'gun cotton' which is used as an explosive. Cotton is also acted upon by salts of aluminium and of tin, and after such treatment is able to absorb and firmly retain many kinds of dyes, which is a property made use of in the employment of alum and chloride of tin as mordants. Considerable inferior cotton and the fuzz called 'linters' is turned to commercial use, as raw material in the manufacture of artificial silk.

Cotton seed and products.—The most important product of the cotton plant other than the cotton itself is the cotton seed. As the seed amounts from two to three times the weight of the cotton lint on the seed cotton, the magnitude of the huge production of this article as a world's commercial product may be imagined. The cotton seed consists of the outer fluff or fuzz (in the fuzzy seeded cottons), the shell or hulls and the meat or kernel inside. All these three parts are commercially made use of. The fluff is removed by special machinery and under the name of 'linters' these short fibres are used for felting and other purposes. The hulls are used as feed for cattle and pigs or burnt as fuel. The kernel or meat is pressed for oil and the oilcake is a valuable cattle feed and can also be used in various forms as a human food. From about 2,000 lbs. of American cotton seed the yield of the above mentioned materials will be as under:—Crude cotton seed oil 300 lbs; oil cake 813 lbs; hulls 725 lbs; linters 35 lbs; the remainder being wastage.

The cotton seed oil yields, on refining, the finest grades of both cooking oil and salad oil, besides considerable inferior oil fit for soap making. The refined oil is also largely converted by deodorising and hydrogenation into solid vegetable fats (and 'vegetable ghee') and finds use in this form in the preparation of margarine. The chemical and physical constants of cotton seed oil are as below:—Specific gravity 0·92; refractive index 1·47; saponification number 191 to 196; iodine number 105 to 115; Reichert Miessel value 0·7 to 0·9.

The oilcake is used principally as a cattle feed and the Indian decorticated cake will contain about 38 per cent of albuminoids, 24 per cent of carbohydrates, and 13 per cent of oil. The

composition of American cake in the same constituents is given as under :—albuminoids 43 per cent ; carbohydrates 22 per cent ; and oil 13·5 per cent. Cotton seed is decorticated or deprived of the hulls before it is pressed for oil and the cake prepared without such decortication is considered harmful to cattle in Europe, which is the largest market for both seed and cake. In India however the cotton seed itself is fed to cattle and the seed forms an important part of the ration for both working cattle and milking cattle. Indian animals thrive on the feed and no deleterious effect due to the presence of the hulls is experienced. There is however a prejudice against the use of the fuzzy seeded American cotton seed as a cattle feed in certain parts of the country, in the belief that this seed impairs the night vision of the animals. Actual experiments have however shown that no such injury results and that these seeds can be fed quite as well as the smooth seeds.

The bark of the cotton plant yields a tough fibre of considerable length, and at one time the use of this material for making rough paper and for being woven into coarse fabrics for wrapping cotton bales was seriously considered. The bark of the stem and of the roots is said to possess medicinal properties as a substitute for Ergot.

Production and trade.—Cotton is grown in nearly every province in India. The approximate acreages in the main cotton growing tracts are as shown below:—Central Provinces and Berars 4,100,000 acres ; Bombay 3,800,000 acres ; Madras 2,500,000 ; Panjaub 3,100,000 ; Sindh 970,000 ; Hyderabad State 3,500,000; Mysore 80,000 ; Bengal 58,000 ; United Provinces 581,000. The total area in British India (1937-38) was returned as 15,357,000 acres.

India is both an exporting and an importing country with regard to cotton. The exports which are very large consist mostly of the short staple indigenous cotton and the imports comprise mostly the superior long staple cottons The imports and exports in the year 1939-40 were as below ; Imports 134,451 tons valued at about Rs. 12 crores, and exports 487,764 tons valued about Rs. 29 crores.

II. SANNHEMP (Crotalaria juncea).

VERNACULAR NAMES FOR SANNHEMP: *Kannada*-SANABU ; *Tamil*-SANAL ; *Telugu*-JANUMU ; *Malayalam*-WUCKOO, *Hindustani*-SAN.

The sannhemp which is also called 'Bombay hemp', and sometimes 'Benares hemp', 'Warangal hemp', 'Devaguddy hemp' and so on, is one of the important fibre yielding crops of India, and as a bast fibre, ranks next to jute. To a certain extent,

though very small as compared with its cultivation for fibre, it is cultivated for use as a green manure crop. In recent years the plant is being cultivated in many tropical countries for the sake of green manure. It is also a very good fodder crop, and is fed both green and dried like hay or is grazed in the field.

Soils.—It is cultivated both on the plains and on the plateau of Mysore and generally in the tracts of moderate rainfall. Soils are generally of the heavy types, clayey loams, and the black fertile rice soils, but very good crops can also be seen on the red loams and the light alluvial loams with a considerable admixture of sand. Where it is required for green manure purposes, whether for rice, sugar-cane or garden crops it is sown on soils of all the ordinary types without any special preference. In Upper India especially in the U. P. where the crop is grown on a large scale for the sake of its fibre, the soils are generally of the light alluvial type. The cultivation is carried on extensively in the U. P., Bihar, the Central Provinces; the U. P. alone accounts for about two-thirds of the produce exported.

In Mysore its cultivation is mostly as a green manure crop preparatory to rice and occasionally sugarcane or potatoes. In certain Taluks like Gubbi, Tiptur, and elsewhere where there are professional weavers of the sannhemp fibre who can work up the fibre into cordage, and woven fabrics, the crop is grown for the sake of its fibre. Rice fields and cocoanut gardens which can be irrigated or on which rain water flows and can be properly conserved are mostly put under sannhemp.

Sannhemp as a fibre crop.—Sannhemp is raised as an irrigated or semi-irrigated crop. It can be grown as a rainfed crop but this is seldom done. A few rows are sometimes sown as a mixed crop in the fields of ragi and jola and this furnishes the seed supply for the irrigated areas. The sannhemp crop grown in this way is generally quite as good as may be seen in irrigated cultivation, if only the rainfall is favourable.

Sannhemp takes about four to four and a half months to mature fully till it can be harvested for seed; but whether grown for fibre or for green manure it is not allowed to occupy the ground for more than three and a half to four months. As a green manure it is cut even when it is two months old, if the sowing of the main crop of rice or sugarcane cannot be delayed but ordinarily it is left for nearly three months, for this purpose. For fibre the period differs considerably; it is cut when the pods are ripe by some and by others when the pods are forming. The seeds are either gathered or not according to the harvesting and retting practices which may be customary, that is, according as dead ripe or young plants are harvested.

The sannhemp crop is generally followed by rice, or if the supply of water in the tank is not ample by ragi or jola. In the case of the cocoanut gardens if a subsequent crop is raised at all it is either ragi, jola or groundnuts.

Sannhemp is grown generally in the main monsoon season or as an early monsoon crop. The preparation of the field is not as thorough as for other crops and generally considerably less attention is bestowed on it than on the main crops. The field is ploughed twice soon after the first rains in April, or the field is watered once to soften the ground and then ploughed. In the ploughed field seeds are sown broadcast at the rate of 60 to 80 pounds per acre and covered by another ploughing. The seeds sprout quickly and in four days are well above ground. Enough undergound moisture is present in the rice soils for the growth of the crop in the early stages, but as it grows up irrigation is given by flooding the field to soak it thoroughly. An irrigation once every fortnight will be required in case there should be no rain. The crop is generally not deemed sufficiently important to be irrigated in this way, but unless irrigations are given the growth will be very moderate, and the plants do not attain the necessary height. With good irrigations however the crop grows very luxuriantly and, if the sannhemp moth which usually works havoc in the sannhemp crop, does not attack it, a very heavy tonnage can be obtained, the plants growing seven to eight feet high, and the stems too fairly thick up to ½ inch in diameter. For extracting fibre the plants are pulled out when the flowering is finished and the pods are forming; elsewhere the plants are allowed to stand until the pods are ripe and seeds can be gathered. The former should however be considered the correct stage for fibre of good quality. After the plants are pulled out they are allowed to dry on the field for a few days, or taken to the retting tank without being allowed to dry. They are tied up in bundles and submerged in the retting tank or stream or pond and weighted down with stones or fastened down with pegs. Retting takes about a week to complete. The plants are now taken out and the bark or fibre is peeled off in a long strip from the root end upwards. If the retting has been satisfactory, the fibre peels off smoothly from the inner stem and likewise the adhering tissues in the surface of and in between the fibres are also well loosened, so that they can be separated by beating and washing. This is indeed the next process; the fibres are beaten on a stone and washed in the water, somewhat in the manner of an Indian 'dhobi' washing clothes; bits of the inner stem, outer tissues and other material are by this means removed and the fibre is available in clean long lengths. The fibre is dried, put up in twists and preserved for use or sent out for sale.

For fibre with good colour, strength and smoothness the plants will have to be cut long before the seeds ripen or rather when the flowering is finished and the pods are forming; they have to be put out for retting without drying and the retting is to be done in clean water, whether still or running. In the field itself the sowing has to be very thick so that the plants will grow very tall without branching. The yield of fibre is

about 350 to 400 pounds as an average but may go up to 800 lbs., in good crops. The fibre as marketed has a large percentage of tow and bits of sannhemp stems, and is rather uneven in colour owing to the inefficient retting and the impurity of the retting water. Though the length is good and ranges from three to five feet, the fibre as sold is a tangled mass, except where retting is incomplete and the fibre is sold in matted ribbons. When retting is complete and the retting water is clean, then the fibre is almost white in colour; but as ordinarily prepared the colour is poor and is almost brown, due chiefly to dirty water.

Sannhemp as a green manure crop.—Where the sannhemp is grown for green manure it may not be necessary to sow the crop so thick, as branching is no drawback. As a matter of fact a special branching variety is what is greatly esteemed for this purpose. In erect non-branching varieties, a little grazing is allowed or the tops are cut away by slashing through the field with a sharp sickle; by both these methods the plants are topped and branching is encouraged. Very tall plants become rather unmanageable when the plants are to be ploughed into the soil. Thick sowing is however the general practice, so that a large tonnage of young easily decomposable growth can be obtained within about two or two and a half months.

Sannhemp is seldom manured; but a dose of superphosphate of about 1½ cwt., per acre may be advantageously applied to the crop and the growth encouraged. This manuring may also be expected to stimulate the crop to assimulate more nitrogen from the air and to develop the formation of the root nodules. Where the crop is to be ploughed in and rice cultivated thereafter, the phosphate manuring may be given in this way, rather than by direct application to the rice crop in the usual way.

The time to plough in the crop is just when the flowers have begun to appear over the whole crop. The weight of green matter is almost at a maximum at this stage and is sufficiently tender to decompose easily in the soil. The material is ploughed in the usual way in the flooded field, where it is trampled into the soft mud as the ploughing progresses; or it may be pulled out, laid on the puddled field and then trampled in, after the field has been well ploughed in puddle. It may also be laid in bundles in the plough furrows and covered over when the adjoining furrow is ploughed. In garden cultivation, especially for potatoes it is usual to chop it up and mix it with the soil just as cattle manure is worked into the soil.

Yield.—The yield of green material in a well-grown crop of sannhemp about two months old may amount to two to three tons per acre.

Sannhemp as a Green Fodder.—Sannhemp furnishes considerable green fodder to cattle. When grown as a green manure it is usual to allow the cattle to have a bite, so that the tender tops are grazed; what is left is allowed to grow further and

branch out or ploughed in straight away. Sannhemp is also cut green and dried like hay. It is stored in the stacks of rice straw in alternate layers with the straw, so that the fodder may be fed as a mixture of sannhemp twigs and leaves and rice straw. Being a quick growing green manure crop, it is sometimes sown between rows of sugarcane and after six or seven weeks is cut down and incorporated into the soil as green manure. Like many other green manure crops sannhemp manuring is a cheap and quick method of increasing the organic matter in the soil.

Botany and Varieties.—Sannhemp—Crotalaria juncea—belongs to the natural order Leguminoseae and the sub-order Papilionaceae. It is a tall-growing plant with a straight thin stem of about ¼ inch in diameter, which attains a height of up to eight feet when well grown. The stem has a very thin outer skin which contains the long bast fibres. The inner stem is woody and is a hollow cylinder filled with pith. The plant is deep rooted, with a long taproot and numerous branch roots, all covered over with many nodules characteristic of leguminous plants. The leaves are small, narrow and lanceolate and are attached to the stems with a very short petiole. Branching is usually limited but is free when the plant is topped. Some varieties are however more branching naturally. The inflorescences are borne in yellow clusters terminally at the ends of the main stem and branches and are typical of the papilionaceae in structure. Sannhemp flowers are self-sterile and depend on cross-fertilisation mostly by insect agency for fertilisation and the setting of the seed. The pods are small, rounded and cylindrical, about two inches in length and quarter of an inch in diameter. When the pod is dry the seeds move about freely inside and rattle when shaken, from which property the name Crotalaria (from a Greek word meaning a 'castanet') is given to this class of plants.

Several varieties are under cultivation, which differ in their period of maturity, being either early or late, in their branching habit, and in the quantity and quality of fibre which they yield. The early varieties take about 80 days to ripen from sowing while the very late ones take about 120 days and the medium ones about 100 to 110 days to mature.

Pests and Diseases.—The sannhemp crop is subject to both insect pests and fungus and other diseases which are very destructive to the crop. Among the insect pests the commonest is the sannhemp moth—*Utetheisa pulchella, L.*—the caterpillars of which feed on the leaves and seriously damage the crop. The caterpillars also feed on the pods in the grown up plants and prevent seed formation. The defoliation is however the more common and causes more serious damage as the plants are greatly weakened and practically cease to grow further. Instead of a leafy thickly growing crop of normal plants only thin sticks either leafless or with only the cellulose framework of the leaves are left.

The caterpillars of two other moths also cause the same kind of injury. These are *Argina caribraria*, C. and *Argina syringa*, C; all three kinds are day fliers and are seen flying about in sannhemp fields. The capturing of the moths by means of hand nets, and in bad cases the spraying of the crop with stomach poisons are control measures; but for a green manure crop these are too troublesome and expensive and are seldom resorted to. The damage is however general and serious.

The borer—*Laspeyresia pseudonectis, M*—bores into the top shoot of the plants and causes considerable damage every year, especially in the Central Provinces. Certain strains of sannhemp have however been found to be less subject to this pest than others and one species—Crotalaria retus—is said to be quite immune to the pest.

A green sap-sucking bug—*Ragmus importunitas, D.*, a flea beetle, a green semi-looper caterpillar, and a pod-boring caterpillar are all occasional pests on the sannhemp, generally of very minor importance.

The sannhemp is subject to serious diseases also, *viz.*, 'sannhemp wilt' and 'sannhemp rust'. The wilt is very general and in some years very destructive. As in the case of the cotton wilt and 'togare' wilt, whole plants both young and grown up become attacked and dry up completely. The sannhemp rust also does great damage, leaves, stems and fruits all being attacked. For neither of these diseases are any remedies known. Strains resistant to wilts in varying degrees however are found and remedies have to be looked for only in the evolving and cultivation of such varieties.

Chemical Composition and Uses.—The fibre is made use of in India for cordage of all kinds, for woven goods like rough cloth, grain bags, awnings and crude tent cloths, and for making fishing nets. It is used as a substitute for jute, to some extent; it is light coloured, coarser and stronger and lasts longer than jute. Ropes made of sannhemp fibre are very strong and are very resistant to the action of water. The ropes are largely used for 'charpoys' or cots, and the fibre is in recent years being used for making twine. It is finding extensive use at present for the making of camouflage nets. The fibre is likely to increase in importance as a source of cellulose, in various industries like rayon or artificial silk, which use cellulose as the raw material. The cellulose of sannhemp is classed as a pecto-celluluse and amounts to 80%. It is a valuable raw material for making paper of great strength, especially wrapping paper.

Production and Trade.—The sannhemp fibre is classed as a 'soft' fibre in contrast with the 'hard' fibres of sisal, agave and Manila hemp, which latter are largely replacing the 'soft' fibres in the trade. Though less important than formerly Indian exports have been steadily increasing during the last few years, and have risen from an average of 15,000 tons per year during

the period 1932 to 1934 to an average of 37,000 tons a year during the period 1935 to 1938 and amounted to over 40,000 tons in 1939-40 valued at Rs. 74 lakhs.

The acreage in Mysore is very small, but that in Madras is about 216,000 acres. The crop is very much more important in Northern India as already stated, the Partabgarh district of the U. P. being an important tract.

III. PUNDI (Hibiscus cannabinus).

VERNACULAR NAMES FOR PUNDI:—*Kannada*-PUNDI, *Tamil*-PULICHAI, *Telugu*-GOGU, *Hindustani*—PATWA.

Pundi is the plant from which the fibre called Bimblipatam jute is extracted and is an important fibre crop yielding a bast fibre of great commercial value. The crop is grown on a large scale only in the Northern Circars of Madras Presidency and fibre produced for export. It is a crop of some importance in the Central Provinces and Bombay, the fibre from which is sometimes referred to as Deccan hemp or Ambari hemp. In Mysore it is grown only on a small scale, sufficient to meet the needs of individual farmers in respect of ropes, twine or loose fibre. The leaves, tops and tender branches are greatly esteemed as a cattle fodder and believed to be specially valuable for cows and buffaloes in milk; where the crop is grown on a large scale it is partly made use of for this purpose also. The leaves and tender shoots and young fruits are also eaten by people, cooked like ordinary pot herbs or in chutneys and curries.

Soils.—It is a crop mainly of the black cotton tract where it is grown as a purely rainfed crop and in rows subordinate to main crops of jola. With good rainfall and on deep black cotton soils the plant grows with great luxuriance reaching a height of even ten feet, with branches springing from near the base almost equally tall. It is grown to a considerable extent as a semi-irrigated crop in sugarcane fields both on the margins and in among the cane rows themselves. The soils in such cases are of varied types and grades of clayey loams, light alluvial soils and red loams. On these sugarcane fields the plants make remarkably tall and luxuriant growth and furnish in addition to very good fibre a good amount of branches and trimmings for use as fodder.

As the crop is grown as a mixed crop subordinate to ragi or jola on dry lands and with sugarcane in irrigated fields, there is no preparation of the field specially for this crop. In the jola field or the black cotton soils the crop is sown through the seed drills and alternates with five rows of jola, that is, the 'pundi' rows are about six feet apart. The sowing is in the months of June-July. On the red soils with ragi the sowings are late or early

according as the tract is one of the late or early rainfall and the ragi crop is of the main season or of the early season. In any case sowings are not earlier than May or later than July. The 'pundi' rows are about the same six feet apart. In the sugar-cane fields the seeds are sown either at the time the cane is planted about the month of May or later on especially on the margin around the field, about June. The crop in all these cases shares in the weeding, manuring and irrigation given to the main crop. The crop grows rapidly and begins to flower from the second month; flowering is from the leaf axils on the main stem and goes on simultaneously with the growth in height. The plants take five and a half months to six months to become ready for cutting. They remain for six to eight weeks in the fields after the main crop of jola or ragi is harvested. The plants begin to dry down at this time and have to be cut. At this stage the stem attains a thickness of two inches in diameter at the base and about half that thickness along the upper portions. The plants are cut at the base and brought over to the threshing floor where they are stacked. They are taken out of the stack after the threshing of the grains and pulses is over, usually about March or April. The plants are spread on the floor and beaten with sticks to break open the dry fruits and dislodge the seeds. The plants are shaken out to further free the seeds and after these are gathered and removed, the stalks are taken to the retting tank or stream for preparing the fibre. The stalks are tied into small bundles and kept under water. They are weighted down to keep them submerged under water completely, and are kept in this way for eight days. The bast is now quite loosened from the stem and can be easily peeled oft in long strips. If the retting has been satisfactory the gums and tissues binding the fibres are well decayed and can be removed by washing and beating the long strips in water. The clean fibre is now dried in the sun until quite dry and is put up in large plaits and stored. The seeds are used as a cattle food; the seeds are soaked in water, softened and ground into a mash and fed to milking cattle, whose milk flow this feed is believed to increase.

Yield.—When grown as a pure crop, the yield of marketable fibre may amount to 1,000 lb. per acre, as a maximum. As ordinarily grown in mixtures the yield varies a great deal but seldom goes above 200 lbs. an acre. The outturn of fibre is about 16 per cent on the weight of the dry stalks.

Botany and Varieties.—There are a number of varieties in cultivation but these are seldom grown pure. The varieties comprise broadly two, *viz.*, a green leaved one and a reddish leaved one, in both of which the colour of the stem corresponds to the colour of the leaves. In both these varieties two types can be seen, one with cordate and entire leaves and the other with deeply lobed palmate leaves; even in the latter, the lower leaves

may be entire and only the upper leaves palmate. There are very tall growing types, and medium or even short stemmed types. The red stemmed green veined variety was found to be the best for fibre in tests made in Coimbatore. The flowers in all cases spring from the leaf axils along the main stem, the sepals are bristly, and lanceolate, the petals from light yellow to light cream in colour, with a dark eye in centre. The capsules are globose, pointed and bristly at the tip. Both leaves and fruits and young stems are sour to the taste and are cooked and eaten as pot herbs. There is another species "Hibiscus sabdariffa" which has deep red almost dark flowers and capsules and which yields the fibre called "Roselle."

The fibre of 'pundi' is rough and strong, with a breaking strength estimated to be from 115 to 190 lbs. The fibres are from five to ten feet long and bright and glossy. Though it resembles jute it can stand considerable under—water usage and is much used for making fishing nets.

The largest use of 'pundi' fibre is for cordage of various kinds. On a small scale, both rough sackcloth and canvas are also made from the fibre. The seeds find use as a cattle feed.

The area under cultivation in Mysore is small and no separate accounts are recorded regarding the acreage. In Madras the area is estimated at over 50,000 acres,

IV. AGAVES.

VERNACULAR NAMES FOR AGAVES :—*Kannada*-KATTALE, *Tamil*-KATTALAI, ANAI KATTALAI, *Telugu*-KALABANDA, *Malayalam*-WAKKUCHAN, *Hindustani*-RAKKASPATTE.

Considerable fibre for cordage of various sorts in South India is derived from the "agaves" of different species and is referred to under the general name of aloe fibre. The agaves are however quite different botanically from the aloes although both resemble each other very strikingly in their habit of growth, as large crowded whorls of long fleshy leaves with spiny tips and margins which appear to spring from the level of the ground. The true aloes are generally sources of an important and characteristic drug which their fleshy leaves yield. The agaves on the other hand yield as their most important product the famous fibres of commerce called sisal hemp, Mauritius hemp, and so on. Many species of the agave are to be met with in South India, the most notable one being the "Agave Americana" familiarly known as the "railway" aloe, because it has been planted on both sides of the railway lines as a fence. This agave has been used extensively as hedges in gardens, fields and plantations. As a hedge plant, it is very efficient and forms a

powerful barrier against the inroads of cattle; it is only incidentally that that it is made use of for the extraction of fibre. It is however this agave which gives the bulk of the aloe fibre produced in this part of the country. Other agaves are also found in South India, notably the green aloe "Mauritius hemp", the Fourcroya gigantea, and several ornamental species. "Agave sialana", the most important agave and the source of sisal hemp is also found, and in recent years has been grown on a large plantation scale in Mysore and Coorg, and fibre extracted by quite modern up-to-date machinery. The most important plantation was one near Fraserpet in Coorg and another was near Gunjoor about fifteen miles from Bangalore. Both plantations were producing very high grade fibre on a factory scale but had to be closed after some years on account of the fall in the price of the fibre. The production of the fibres survives at the present time as an off-time subsidiary occupation.

Soils.—Sisal and the other agaves are plants well adapted to dry tracts of low rainfall and to rough upland soils which are coarse, gravelly and generally of low fertility and which are not deemed good enough for ordinary agricultural crops. Although on such soils they make good growth while other crops cannot be thought of, still if given the advantage of the better class of soils, they do exceedingly well. As a matter of fact the plantations near Gunjoor were on the deep red loamy soils of this tract on which a variety of agricultural crops are usually grown. However on rich soils the plants are believed to produce large fleshy leaves with a smaller proportion of fibre. They can also thrive under a wide range of rainfall from about 20″ (as in the Babboor Farm in the Mysore State) to about 70″ as in Coorg and the western parts of Mysore. The world's largest sisal plantations are confined however to the fully torrid zone and the Central American States, Mexico, East Africa and Central Africa are the most important tracts of production.

Propagation and Planting.—The agaves are propagated by means of (1) suckers and (2) small plantlets called "bulbils" which are borne on the flower stalks. The grown up plants produce root suckers from about their third year and continue to do so for two or three years thereafter, each plant yielding some twenty suckers in this period. Old plants when they are about 15 years old begin to flower, the flower stalk resembling a stout pole some five or six inches in diameter at the base and quite ten or twelve feet in height. On this mast-like structure which is called the "pole" spring thin lateral growths producing bunches of "bulbils" or small plants which can be removed and used as planting material. After the "poling" the parent plant begins to die down but suckers are sent out from the root, which also provide planting material. The suckers and "bulbils" are generally planted in a nursery and reared therein for a year before they are put down in the plantation. The "bulbils" are very small, being

only about two to six inches in height and have to be grown in the nursery till they are at least one foot high before transplanting.

Plants are put in in their permanent places in the plantation in pits about one foot square and the same in depth. The pits are made at distances of ten to twelve feet each way. Distances of seven feet each way have been adopted in certain plantings but this has been found later on invariably too small for inter-cultivation and convenient handling. The wider planting will be found the best in the long run. When planted as hedge plants they are planted on raised ridges or mounds of earth and at distances of three feet from each other in a line or even closer, which makes allowance for considerable damage and casualties consequent on rough conditions and neglect. The planting is done in the months of August and September, when the ground is soft enough to dig after the rains of the south-west monsoon and the young plants have the advantage of the later or north-east monsoon rains to become sufficiently well established to withstand the following hot weather. Plants put upon the ridges have to be protected from being washed down or dislodged in the rains and the mound itself well tamped on the sides against erosion. In the field planted solely for the sake of the fibre, the interspaces have to be kept weeded or cleared of the larger bush growth. In large plantations where the plants are put in wide, at intervals of twelve feet, the interspaces are also ploughed and minor crops of groundnuts, cowpeas and so on raised during the first two years. During the fourth year, the plants are old enough to yield leaves which can be cut. A large number of root suckers also come up and these have to be systematically removed; if this is neglected the interspaces may become covered with suckers coming from all around the parent plants. About twenty to thirty leaves can be cut in the first year of harvest from each plant and this number will increase as the plants grow older. The leaves to be cut are the lowest ones and these can be cut when they are slanting more than 75° from the vertical. Those at right angles and those that droop are more mature. Harvested in the fourth year on plantations in tracts of heavy rainfall like the coffee estates of Mysore, the plants gave on the average 40 leaves each, with a maximum of 62 leaves and a minimum of 25 leaves per plant. In the following year also they yielded at the rate of 38 leaves per plant on the average. The green weight of the leaves in the first year was, ·76 lb. per leaf while in the second year the weight was almost double, *viz.*, 1·4 lbs. In a tract of low rainfall of about 20″, the plants yielded at the first harvest, that is, the fourth year after planting, at the rate of only 30 leaves per plant with an average weight per leaf of about ·5 lb. per leaf. The harvesting of the leaves usually begins in the month of January and goes on till March or April.

The agaves (sisal and others) go on yielding for about 15 years under normal conditions and then begin to flower or 'pole', after which they die down. Many causes however bring about a premature "poling" and such plants become useless long before their time and if the premature "poling" is very early and general it spells disaster. The cutting of a large number of leaves at a young age and the consequent weakining of the plants is considered one of such causes. The non-removal of the root suckers for a long time after they have appeared is also stated to accelerate "poling". There is also a belief that plants raised from bulbils are more likely to "pole" prematurely than plants raised from root suckers, although the contrary too is sometimes believed. Lack of sufficient lime in the soil, wet conditions and want of aeration in the soil are also considered causes. Peculiar conditions of rainfall and weather which are not well understood are probably more responsible, as the 'poling' by a few plants is often accompanied by a somewhat wide-spread 'poling', making it appear the result of weather conditions. The subject is certainly obscure.

Extraction of the Fibre and Yields.—Unlike the fibres considered so far, the source of the fibre in the agave is the leaf. Fibre is extracted from the leaves by two methods, the dry and the wet. The aim in both methods is to separate the long strands of the fibre from the soft pulpy tissue in which it is embedded. In the dry method this is purely mechanical. After removing the tip and the thorny margins of the leaf, the leaf is passed between a hard board and the blunt blade of a knife which is pressed on the leaf surface to the degree required. The leaf is passed several times in this manner and each time the blade is brought closer or pressed lower. The process is repeated until the fibre is completely separated from the adhering tissue. As a preparatory process, the leaves may be bruised all along their length by beating with a wooden mallet and then passed through the extractor so as to render the separation easier. The fibre is then washed free from further adhering matter. In a small way the fibre can be extracted by first dividing the leaves into four or five strips along their length, laying them flat over a board and scraping off all the soft tissue. These methods are of course simple but are slow and too costly to be carried out by paid labour. They are carried out generally by the cultivator himself and to the extent that may be required for his own individual needs. The principle is however copied in the large scale fibre extracting machines of the "Raspador" type by which alone agaves grown on a plantation scale have to be handled. The "New Corona", "Molla" and several other types of machines of British, German and American makes are now in use in sisal growing countries.

The "wet" method consists in allowing the leaves to ret in water in the same way as the fibres of sannhemp,

jute etc., are treated, whereby the soft tissues and gummy matters disintegrate by chemical and bacterial action and the fibres are separated easily. In this method the leaves are put up in bundles either whole or split into long strips and kept immersed in water, being at the same time weighted down with a heavy stone. After twenty days the leaves are ready to be taken out; they are then beaten on a stone, scraped and washed and the fibre separated from both the soft tissue and the tough epidermal layer. This process is much less costly though very much slower. Moreover the colour of the fibre is dull and is much inferior to the fibre made by the dry process, which yields a white and almost brilliant fibre. The fibre yielded by the dry method is about 3 to 3·5 per cent of the green weight of the leaf while that by the wet method is about 4·6 per cent. Grown on a plantation scale an acre of the 'Agave sisalana' in its best condition is expected to yield 10 cwts. of clean fibre. In very dry tracts of poor soils, the yield may seldom exceed 400 lbs. per acre. The life of a plantation is usually reckoned as ten to twelve years. In dry climates under somewhat semi-arid conditions as in Mexico, Yucatan and Central Africa they last up to twenty years. With regular new plantings between the rows of the older plants the life of a plantation can be kept up much longer.

Properties and Uses.—The fibre of the agave is very white and brilliant in colour when prepared properly by the dry method. The fibres are from three to five feet in length ordinarily, but when the plants are not well grown may go down to two feet. The fibre made by retting in water is somewhat dull in colour, but is generally longer than in the dry method. In contrast with other fibres, the agave fibre is clean and free from soft fibres and tow to a remarkable extent. The cordage made from agave fibre cannot stand usage under sea-water nor any prolonged usage under even fresh water. The most important use to which sisal fibre is put is for the manufacture of binder twine, which is used in binding the sheaves in the self-binder harvesting machines which not only cut the grain crop but also deliver it tied up into sheaves of uniform size, as the machine moves along the field. The ropes made of agave fibre are strong and also last a long time and are in great demand for many agricultural purposes such as for 'Kapile' water-lifts, head ropes of bullocks, for the tying of plough parts and so on. Agave ropes have been found very strong with a breaking strength greater than that of coir, cotton or "pundi" (Hibiscus cannabis). Agave fibres are being used for the making of door rugs, bags, awnings, soles for sandals, etc. In cellulose content agave fibre ranks rather low having only 75·8 per cent.

The inner stem of the agaves is edible; in times of famine poor people boil and eat it. It is a favourite food for pigs and much damage is caused to aloe hedges by wandering swine-herds who

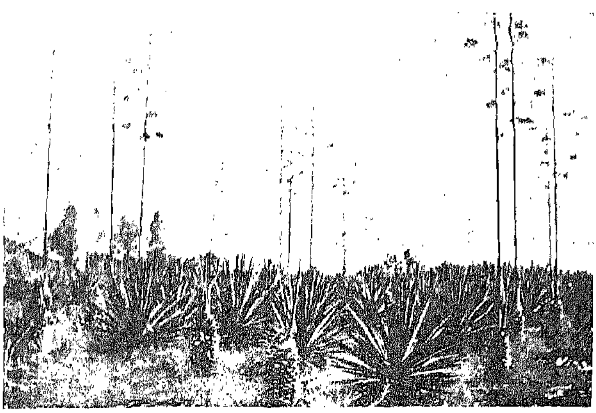
uproot the plants and allow the pigs to feed. In plantations situated in tracts visited by wild elephants these cause great damage and sometimes wholesale destruction. In some countries the stem is tapped for the sweetish juice, which is converted into an alcoholic drink by fermentation.

Botany and Varieties.—The agaves belong to the order Amaryllideæ, to which also the other important "aloe" fibre plants such as those of the species 'Fourcroya' belong. The "railway aloe" is the Agave Americana, the Sisal is the Agave rigida, var., siasalana; A. Mexicana also yields an important fibre while A. variegata is an ornamental plant as well. Belonging to the species Fourcroya are the F. gigantea, F. variegata, and F. longæva. The green alœ or Mauritius hemp is also referred to as A. cantala. The agaves are plants that appear to consist of nothing more than a cluster or whorl of leaves springing from ground level like a rosette. The leaves are however crowded densely around a thick sappy stem, which is short, single and unbranched and is completely hidden by the leaves. The leaves themselves are thick and fleshy, long and narrow, with a spiny tip and often a more or less spiny margin. The leaves are flat or with a deep central groove running the whole length of the upper surface. The leaves are very strong, and are from three to five or even six feet long and about four to six inches wide. The width is more or less uniform throughout and narrows only towards the pointed tip. The leaves are smooth and glaucous, green or bluish with an ashy gray bloom on the surface. The flowers are borne on a pole-like scape in fascicles. The perianth is six-lobed and funnel shaped, the stamens are six in number, the stigma is three—lobed and the ovary is three-celled and inferior. This character, *viz.*, the inferior ovary distinguishes the agaves from the true alœs with which they are generally confused and which have a superior ovary though in other respects both are very similar. Fruits are normally formed and contain numerous black flattened seeds. Frequently however bulbils or plantlets are formed instead.

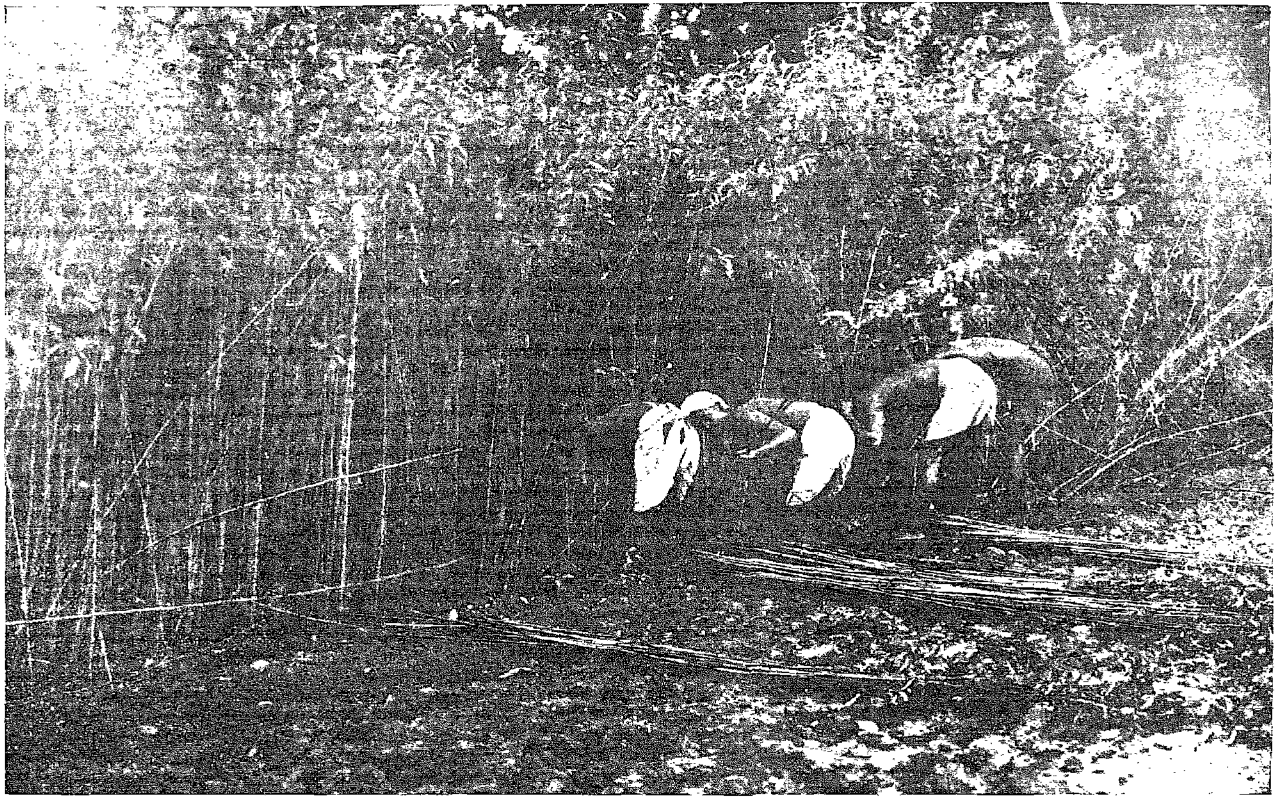
Pests and Diseases.—The agaves are not subject to any serious pests. The shoot is sometimes attacked and bored through by a beetle resembling the rhinoceros beetle; when the shoot grows and the leaves unfold the latter are found to be cut through by holes about an inch in diameter. Leaf spots are also found, due to a fungus disease; these spots or patches widen gradually, become black in colour, dry up and form a hole on the leaf. The disease can be controlled by spraying with Bordeaux mixture.

Areas and Trade.—Though plantations were started in several parts of India such as near Kurla in Bombay, near Hindupur and Salem in Madras, in Gunjur near Bangalore in Mysore and near Fraserpet in Coorg at various times during the past thirty years they had to be abandoned after some years of

Young Sisal hemp plantation.
[From the "Tropical Agriculturist," Ceylon Agri. Dept.



The "poling" of sisal hemp.
[Photo by Author.



Cutting Jute.

successful working, due among other causes to low prices of the fibre. Throughout these tracts and South India generally millions of agave plants of different kinds exist, from which considerable fibre is extracted and utilised as a domestic or subsidiary industry. There are also some rope-making factories handling the fibre. There is a fair amount of import trade in the fibre. In the year 1937-38, the quantity imported was 45,827 cwts. valued at Rs. 8,23,160.

V. JUTE (Corchorus capsularis).

VERNACULAR NAMES FOR JUTE:—*Kannada*—GONI; *Bengalee*—PAT, PATA, KASHTA.

One of the most important commercial fibres of the world, which is also peculiar in the fact that its cultivation is entirely confined to India is Jute, called also Bengal Jute. Its importance in India may be judged from the value of the quantity of raw and manufactured jute annually exported from India, which in the year 1937-38, amounted to some 43 crores of rupees. The history of the cultivation of jute in India and the growth and development of its manufacture in the country is remarkable in that the crop has within less than a century risen from being a comparatively insignificant crop raised for furnishing the rough cordage and woven fabrics required for the domestic needs of the cultivator to one that is now among the foremost industrial crops of the world. Its cultivation is also peculiar in that it is confined to one particular tract of India, *viz.*, the north eastern corner of the country in the provinces of Bengal and Assam, in the extensive river delta of the Ganges and the Brahmaputra rivers. Its cultivation has been attempted in many other parts of India and in many foreign countries but has everywhere failed to establish itself or assume any material importance. India therefore commands a monopoly of the jute supplies of the world. Measures adopted with the object of breaking this monopoly have been the attempted use of many substitutes like other fibres and paper, and the method of handling grain and produce in bulk, thereby avoiding the need for bags. These have in no way reduced the importance of jute nor its world-wide demand.

Distribution.—The jute plant is considered to be native to the coastal tracts of the Mediterranean Sea, though in India itself it was known even in Vedic times. The fact that at present its cultivation is confined to Bengal and that attempts to introduce it in other parts of the world have not been successful as commercial enterprises cannot be taken to prove that no other part of the world is suitable for its cultivation. As a matter of fact jute cultivation has been found possible in many countries

such as Formosa, China and even Japan, Thailand (Siam) Egypt, Iran, Paraguay and Brazil, showing that it can grow as far north as even Japan and north China. Agronomically its cultivation is thus possible over many different parts of the world. It is the other advantages which Bengal enjoys *viz.*, its unlimited resources in cheap and skilled labour accustomed to the exacting methods of its cultivation and especially the extraction of the fibre, its unparalleled facility in regard to water for retting, for cheap transport and for irrigation, the technical knowledge and practical skill in every detail of its cultivation and manufacture, the great hold it has secured in the world's markets by virtue of its long established character, the vast areas of land available in such an advantageous tract and such economic or extra-agronomic factors that operate in favour of Bengal as against other parts of the world.

Outside of India its cultivation is therefore negligible. In India itself fully 90 to 95 per cent of the total area is to be found in Bengal and Bihar while the remaining 5 to 10 per cent in Orissa, Assam, Cooch Bihar and Tripura. Even in Bengal the bulk of the area is concentrated in a limited tract, lying east of a line extending from Purnea to the 24—Pargannas and west of a line extending from Goalpara to Noakhalli.

Climate.—The climate of the above tract and indeed the soil and other conditions as well have to be considered the most suitable for jute. "A warm and damp climate and yet not too much or incessant rainfall"—this is a description of the climate of the jute tracts. The tract is nearly all at sea level or within an elevation of 200 feet at the most. The rainfall ranges from 50 to 70 inches in the year and the rainy period extends from March to October, and the other months are not altogether rainless. Sometimes there may be early rains in February itself to permit of ploughing the land. Atmospheric temperatures during the rainy months are rather uniform around 83° F., while in the cold season the range is from 68° to 75° F., the yearly mean temperature being about 78° F. These figures relate to Dacca and may be taken as typical. Much land is subject to floods and submersion, but the jute crop flourishes without any detriment even under such conditions, the growth being luxuriant though the fibre may be somewhat inferior. The bulk of the land is however high lying and not subject to flooding.

Soils.—Jute soils are all mostly deep river alluviums very fertile naturally, which get in addition a deposit of silt with the floods of each year. They are mostly light sandy loams. The crop however can be grown on practically any kind of moderately good soil, provided it is not highly gravelly or lateretic or very sandy. Some strains of the plant are able to grow even when there is considerable salt in the soil.

Rotations.—The jute crop has to be grown under a definite system of rotation, and a succession of two jute crops one after

the other on the same land without a rotation has been found to be detrimental. On land not liable to flooding the rotation crops are one or other of the following, *viz.*, rice, wheat, tobacco, pulses, barley or oats. On land subject to flooding, lowland paddy suited to this class of land is the only crop fit for rotation.

Cultivation.—The earliest sowings of jute are made in fields subject to flooding and this is usually in the month of March. The preparation of the field has to be from March onwards and depending upon the situation of the field sowings may continue up to the month of June. With the rains of the different months the fields are ploughed and cross ploughed several times, clods broken, and all weeds collected and burnt. Cattle manure and household refuse and sweepings are applied as much as may be possible and this together with silt and river mud from the canals and ponds forms about the only manure. After the manure is worked in, the field is levelled by levelling boards and made ready for sowing. Jute seed at the rate of about 9 or 10 lb. per acre is sown either in rows about 9 inches apart or by broadcasting. In the latter case the young crop has to be thinned out considerably by means of toothed hoes. The seeds sprout in four to seven days and after the young crop shows well above ground interculturing between the rows is carried out twice at intervals of a fortnight and later on the field is handweeded. The plants are left standing at distances of about $9'' \times 4''$ as the result of these operations. When the crop which was sown broadcast is thinned out the stand is also more or less the same, or a little closer, *viz.*, $5'' \times 5''$, or $4'' \times 4''$. It is also sometimes the practice to sow a nursery and then transplant the seedlings. In five or six months after sowing, the crop is ready for harvest. The harvest of the early sown crop begins in July and continues throughout August, while for the main season crops, harvest is in the months of August and September. Including the harvest of the late varieties, the harvesting of jute may be said to go on from about July up to even November.

Both quality and quantity of fibre are influenced by the stage at which the crop is harvested. The best time to cut is when the fruits have just formed; if cut earlier the produce suffers in quantity, and the fibre lacks strength though it has a good white colour. If cut late the fibre is coarse, lacks colour but the yield is heavier. Generally it is practical convenience which decides the time of harvest by the cultivator, which has to be spread over a much longer period than may be deemed correct. Sometimes for the sake of the seed, crops are left standing until the fruits are quite mature. The fibre becomes very coarse, but a much larger yield is obtained in addition to the seed.

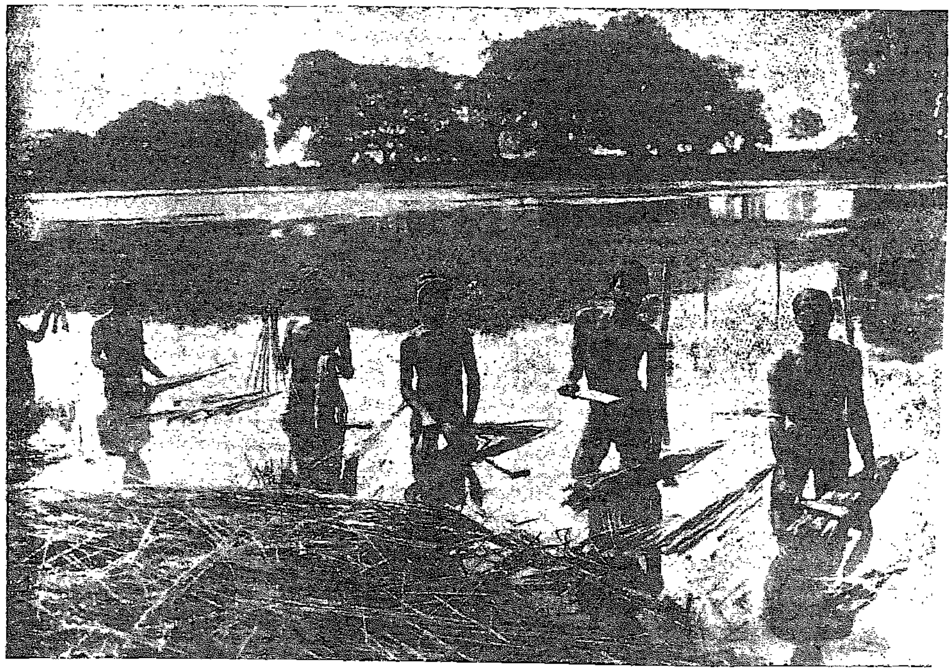
Harvesting consists in cutting down the plants by means of ordinary sickles quite at the level of the ground; in many fields water stands so deep that the men have to dive several feet and

cut the stems down. Plants may also be gathered by pulling them out by the roots.

Extraction of the fibre.—As in the case of the other bast fibres like 'sann hemp' and 'Hibiscus cannabinus', the jute stems have to be retted in water in order to free the bark and to loosen the fibres from the gummy and other adhering material. The harvested plants are for this purpose tied up into small bundles, and kept piled up for a few days, so that the leaves may wilt and drop; they are then trimmed of the top and branches and of the roots, where necessary, and taken to the retting tank, or pool, river or canal margin. Very often the plants are taken straight away without any preliminary stripping of the leaves, as high lying land may not be available for heaping the bundles. The stagnant water of pools and tanks is preferred to the flowing water of rivers and canals, as retting takes place quicker in the former. The bundles are pushed under water and kept immersed by being weighted down with clods of earth, bundles of water hyacinth or plantain stems, as stones are not easily obtainable in these tracts. It is found that the water hyacinth expedites the retting in addition to not discolouring the fibre as is the case when clods of earth are used. As the retting progresses the bundles are examined from time to time to see that the proper stage has been reached and that no over-retting takes place. In about ten days in the hot weather and in a longer but varying period which may extend to even 25 days in the cold weather the retting is complete.

The colour and the strength of the fibre are much influenced by the retting process and the water used for the purpose. If the plants are over-retted some of the gummy matter dissolves, discolours the fibre and renders it weak. Clear water gives a clean fibre of good colour while muddy water, especially when it has been used for more than one retting, spoils the colour. Silt laden waters flowing through ferruginous soils also discolour the fibre. Stagnant water is often used again and again for retting as on account of the increased bacterial action each of the rettings is finished quicker than the one preceding it; the practice however leads to much discolouration of the fibre.

Stripping and Washing.—After the retting is completed the fibre has to be stripped from the jute stems and then washed. This work is very laborious, exacting and requires great skill and practice. The men have to stand waist deep in the water all the time and strip the fibres by hand, handling the stalks one by one or in small bundles of a handful at a time. The method of stripping consists in beating the root ends with a mallet first and after breaking off the stem at this end, and with the free ends of the bundle of fibres caught firmly in one hand jerking the stems backwards and forwards in the water, until the whole length of the fibre is stripped free from the stalks. If handled singly, the fibre is slowly peeled from the root end upwards after



Jute—Bunch Stripping of the Fibre.

Jut   Assorting and putting ... into twists, before bundling.
[Illustrations from the Report on the Marketing and Transport of Jute.   Photos by Messrs. Johnston and Hoffmann, Calcutta.

bruising the root end free from the stalk. The fibres are then washed clean from adhering bits of stem and bark and are taken out for drying. The work is very slow whatever method is adopted and one man ordinarily strips about 40 lb. of fibre in a day.

The washed fibre is hung out on bamboo frames to dry in the sun. About two or three days of sun drying is sufficient to complete the process. The fibres which are in long strands some six to eight or ten feet in length are then made up into small lots by tying them at the top ends and in this condition are ready for sale in the primary markets.

Yield of Fibre.—The yield of fibre per acre varies a great deal in the several districts. A careful inquiry puts down the yield at 12½ mds. an acre. Yields may vary from nine mds. which is low to about 18 mds. which is a very high yield. A good yield may be taken as 15 or 16 mds. per acre.

The stage at which the crop is cut affects the yield materially. Thus, in experiments with the Capsularis variety it was found that harvesting at the bud stage, at the flowering stage and at the fruit stage gave 17 mds. 22 seers, 19 mds. 16 seers and 21 mds. 38 seers per acre, respectively. (1 md.-40 seers-82⅔ lbs.)

Botany and Varieties.—The jute plant belongs to the natural order Tiliaceae, and the genus Corchorus. The genus comprises several species, of which those under cultivation are the 'Corchorus capsularis' and the 'Corchorus olitorius.' Improved strains have been isolated in both species: *viz.*, the one called "Kakya Bombai," and especially D. 154, in the C. capsularis and the strain called Chinsurah Green in the C. olitorius. The two species have many characteristics which distinguish them sharply from each other. Thus the stem of C. capsularis is purple or light green in colour and that of the C. olitorius is light green or pink. The leaves of the C. capsularis are bitter while those of the C. olitorius are edible. The fruit of the C. capsularis are round capsules while those of the C. olitorius are cylindrical pods, and the seeds of the former are oval in shape and deep brown in colour while those of the latter are pyramidal in shape and blue in colour. The fibre of C. capsularis is ordinarily white and is not so soft or strong as that of the C. olitorius. The C. capsularis thrives well on both high lying and low lying land whereas the C. olitorius can be grown only on high land and cannot stand flooded conditions. The C. capsularis is also the more hardy species and is much more adaptable to varying conditions. It is therefore the species grown very largely; about 75 per cent of the jute area is under C. capsularis and the C. olitorius occupies only the remaining 25 per cent. The C. olitorius is however the fibre which is more in demand for export as its fibre is much finer than that of the C. capsularis. In the trade the two species 'capsularis' and 'olitorius' are known by the names of 'white jute' and 'tossa or daisee jute' respectively.

Pests and Diseases.—There are no serious insect pests or fungus or other diseases attacking the jute crop. Occasionally the stems are attacked by small weevils *Apion spp.* These are small black weevils which breed in the stem tunnelling half way round and generally near the axils of the leaves. The attacked plants may become stunted in growth and even wither.

A leaf-eating semi-looper, *Cosmophlia sabalifera,* is also found attacking the leaves occasionally, both leaves and leaf buds being eaten. The growth of the main stem ceases and many side shoots and branches arise. Neither pest is of any serious importance.

Among fungus diseases, the jute plant is subject to the attacks of a root-rot, caused by *Rhizoctonia spp.* The attack is seen in plants in all stages of growth. In the seedling stage the disease is somewhat like a "damping off." In older plants the attack is on the stem at ground level; in the diseased area the outer tissues become black in colour and soft and partially disintegrated. Some leaves are also shed and the plants begin to dry up as though they were ripe and ready to cut. The stems however do not break or collapse. Only preventive measures are possible and these consist in adopting a suitable rotation and avoiding the growing of jute in the infected soil for two or three years.

Chemical Composition and Uses.—By far the largest and most important use of jute is for the manufacture of woven pieces which are made use of packing cloth, hessian and for stitching into bags. These are all in demand all over the world for the wrapping of bales of cotton and wool and holding grains, pulses and other produce and for use as sand bags. Many different fibres and other materials such as coir, sisal, sann and other hemps, cotton, etc., have been tried as substitutes for the purpose of making bags but none has been found as suitable as jute. Recently paper has been substituted with some amount of success for jute in wool packs from Australia and new materials called 'Jutilal' (typha fibre) 'Esparto grass,' 'Ginster' (furze) are claimed to hold out promise. In spite of everything jute undoubtedly reigns supreme. As woven cloth jute is made use of for linoleum, oilcloth, tarpaulins, carpets, rugs and other floor covers, curtains, tapestry, linings and upholstry, etc. As cordage it is used for ropes and twines and as loose fibre for tow, stuffing, theatrical wigs, oakum and so on.

The jute fibre is very inferior to many other fibres in strength. Bags, hessian and sacking all wear out soon by mere usage. Jute fibre is also quickly damaged by damp and rots in contact with moisture and is therefore not fit for under-water use. The fibre takes up dyes readily and can be woven in coloured patterns but the colours fade quickly. It can be also bleached but the bleaching is not permanent and the material soon turns yellow. Jute is also used to mix with flax as an

adulterant in linen. In contrast with cotton and linen, jute has a low content of cellulose and a good proportion of the cellulose is of the inferior lignocellulose kind. The composition of average samples of jute is as under :—

Moisture	Cellulose	Pectic matter	Fats, waxes and gums	Aqueous extract	Ash
9·9	63·9	24·1	0·4	1·0	0·7

Production and Trade.—The total area under jute in India (1939-40) was 3,120,000 acres, made up of the following provincial and State acreages :—Bengal, 2,504,000, Bihar—266,000 Assam—281,000, Orissa—23,000, Cooch Bihar and Tripura—46,000.

The annual production shows considerable fluctuation and has varied between approximately nine million and ten million bales (of 400 lb. each) per year between 1932-33 and 1937-38. It is estimated that the production can be increased to 15 million bales, if prices are attractive and the seasons favourable.

About 60 per cent of the total production is utilised within the country and the remaining 40 per cent is exported. The average yearly exports amounted to 3,978,000 bales, during the ten year period ending 1938-39.

SECTION VIII.

NARCOTICS.

I. TOBACCO. (Nicotiana tabacum.)

VERNACULAR NAMES:—*Kannada*—HOGE SOPPU; *Tamil*—POGAILAI; *Telugu*—POGAKU; *Malayalam*—POGAILA; *Hindustani*—TAMAKU.

The tobacco crop is grown for the sake of its leaves which when used as a cured product exert a mild narcotic and soothing effect on the human system. It is enjoyed and used on this account by people of all races throughout the world. Smoked as pipe, cigar, cigarette or 'hukkah', used as snuff or chewed as a quid in many forms, it is enjoyed by people in all walks of life and all grades of society, by men and women, both old and young. The use of tobacco is however only a comparatively recent introduction to the modern world dating from the Spanish conquest of America. As in the case of the potato, the South American continent is the native home of the tobacco plant and its use was learnt and copied by Europe as the result of the contact of the people of Europe with America. To Sir Walter Raleigh is ascribed its introduction as a fashionable habit into England. Its use and cultivation in India dates from the arrival of the Portuguese in India and both have spread rapidly with the growth of communication by sea and land with western countries.

Distribution and Climate.—Tobacco is grown under a very wide range of conditions; it is as much a plant of the tropical zone as it is of the sub-tropical and temperate zones. On both sides of the equator are to be found some of the most important tobacco growing countries of the world, famous for the choice varieties of the leaf and over the greater part of the sub-tropical temperate zones lie equally important areas notable for the extent and for the varieties grown. As tobacco is only a three months crop it is possible even in the countries of the far northern and southern latitudes to grow the crop, as summer temperatures prevail for this short period at least. The southern and south-eastern States of the United States of America, Canada, Central America, Mexico, the West Indian Islands famous for the Havana tobacco, the Guianas, Brazil, the northern and eastern Republics of South America, the Philippines, Java, Borneo, Sumatra and other parts of the East Indies, the Indo-Chinese peninsula, the Japanese empire, China, India, Persia, Asia-Minor, Southern Russia, Turkey, Germany, Austria, Holland, Belgium, Italy, Spain, Egypt, Rhodesia and many other parts of the African continent, are all countries where tobacco is largely

cultivated. In India the crop is cultivated in every province, including Assam in the east and the North-Western Frontier Province in the west to such a large extent that in the aggregate the Indian production is reckoned as the second largest in the world, and not far below that of the United States of America which is the largest individual producing country. Tobacco can be grown also over a wide range in respect of altitude. In island countries and coastal belts, the crop can be seen growing from sea level and almost up to the edge of the sea as in Malabar and Jaffna, while inland cultivation is carried on with great ease in the Mysore plateau at altitudes of 3,000 feet; in Afghanistan and the Frontier provinces cultivation may be seen at altitudes of even 6,000 feet. In the Dutch East Indies tobacco of choice varieties are grown likewise at altitudes reaching 4,000 feet. The temperature during the growing season for tobacco varies from about 60°F. as a minimum to 100° and even 105° as a maximum. When grown as a rainfed crop tobacco requires only a moderate rainfall. About 20 inches will be enough to see the crop through, if spread well over the growing period. The crop cannot stand a heavy rainfall. It is not grown where the seasonal fall exceeds 40 inches and is therefore not suited for growing in the monsoon season in tracts of heavy rainfall like the malnads of Mysore. The rainfall has to be well distributed over the growing season. Heavy rainfall when the crop is maturing its leaf is detrimental in the case of the ordinary varieties of tobacco for the reason that the rain washes away the resin which forms at that stage over the leaf surface and thereby reduces its quality. The seasons have to be properly adjusted to the requirements of curing also. Usually bright rainless weather is required at this time, although in the method of barn or flue curing this is not all-important. The curing also requires a fair degree of humidity in the air, so that cured leaves do not dry into a brittle condition, making the handling of the leaves without damage almost impossible. Generally a moderate rainfall in the growing season followed by a dry season in which the humudity does no go below 80 is required for tobacco. When it is grown under irrigation the quantity of minimum rainfall is of course not of much consequence but the requirements as regards humidity at the curing period will have to be met. The subject is further gone into in connection with the methods of cultivation and curing.

Soils.—The soils best suited for tobacco are the red, light and ash coloured loams, more inclined to be sandy than otherwise. The typical red loams of Mysore which form the predominant type have been found eminently suitable. Soils of the alluvial type in river valleys, banks and deltas are much esteemed. Drainage is very important as in the case of many garden crops. The tobacco crop has roots which are much sensitive to heavy rainfall or irrigation without adequate drainage. Soils have to

be naturally well drained being underlaid by porous easily percolating deeper layers and by proper situation. When the situation needs it, ample drainage will have to be artificially provided, especially in irrigated cultivation. Tobacco is a deep rooted crop with a wide range of root system and soils have therefore to be deep and uniform in texture, free, from grit, gravel and stones and easy of working. Though the above mentioned lighter types of soil are considered best, soils of the heavier types and even the black cotton soils, and in many foreign countries soils with a large admixture of leaf mould and decaying vegetation and of great natural fertility are utilised for tobacco. In the large tobacco areas of the Guntur District of Madras and in Southern Bombay extensive stretches of black cotton and other heavy types of soil are grown with tobacco.

Rich and heavy types of soils tend to make the leaves larger, thick and coarse and this sort of leaf is not fancied for the thin, light and tough, bright curing kinds required for the cigarette trade. The former have their special uses, equally important and possess their own market. Even on these the lighter cigarette types can be grown with proper changes in the method of cultivation designed with a view to reduce the nourishment going into the building of the leaves.

Tobacco is grown even on exceedingly sandy soils approximating to almost pure sand in coastal regions. On the west coast in South Canara and Malabar, for instance, and in the Jaffna District in Ceylon cultivation may be seen on this type of soils. This crop also commands a special market as chewing tobacco.

As different varieties of tobacco are cultivated, each suited to a different kind of product, such as cigar (wrapper and filler) pipe, cigarette, chewing (dry and pickled) and snuff, as even among these each one has classes and brands suited to different regional tastes and as the soil requirements are somewhat different for these varieties, it is possible in the case of tobacco to adjust varieties to soils. As a general rule it may be stated broadly that the heavy and naturally fertile soils are preferred for the large heavy bodied leaves, used for cigar fillers, pipe, plug and chewing and the light sandy and somewhat less fertile soils for the bright curing thinner and high priced leaves such as are required for cigarettes, cigar wrappers and high grade pipe tobacco. It should be noted however that the composition of the irrigation water somewhat modifies the character of the soil in this respect. Many well waters contain dissolved salts of different kinds such as chlorides, nitrates, sulphates and carbonates and these exert material effect on the quality of the leaf irrespective of the nature of the soils. In Gujarat some of the well waters are found to contain nitrate of potash which favours the growth of the leaves and tends to give very large yields of leaves with a high burning quality.

Rotations.—Tobacco is a crop requiring only three months to harvest from the time of transplanting. It is a crop which is grown both as a purely rainfed crop and as an irrigated crop. When grown as a rainfed crop, tobacco forms the only crop grown in the year. This is due to the fact that the soil is ploughed and reploughed several times, prepared thoroughly during the early and the main monsoon rains and the tobacco planted when the heavy rains are coming to an end. The preparation of the field goes on until the month of August, when the tobacco is transplanted; by the time the crop comes to harvest the season ends and no other crop can be grown. In such cases tobacco is rotated (1) with nearly always a grain crop like ragi, which may or may not be followed in the same year with horsegram, (2) with horsegram or a mixture of horsegram and niger or (3) with 'gingelli'. If the ragi was sown mixed with the usual pulse crop, 'avare' or 'togare' then the ragi pulse mixture forms the rotation crops of the year. On black cotton soils tobacco may be followed by jola, or groundnuts grown either as the sole crops of the year or followed by a second crop of horse-gram, Bengalgram, coriander or onions. As the tobacco crop is grown over only a portion of one's holding it is rotated with a different crop or set of crops each year selected out of this variety. Grown as the single crop of the year, tobacco is often made use of to give a second or ratoon or stubble crop, which springs from the stubble left over on the harvested field, and which though small in quantity is generally considerable on retentive soils Tobacco grown as an irrigated crop is cultivated largely under well irrigation, or from tank or river channels either solely or supplemented by well irrigation. The cultivation over large areas of channel irrigated tracts, where rice and sugarcane are the crops ordinarily grown, has been newly started in Mysore, the variety being the cigarette type 'Harrison's special,' and the crop of green leaves being purchased by the Mysore Tobacco Company for being flue-cured. In these areas the practice of growing two crops of tobacco on the same field, one in the early season and the other in the late season, is being introduced as a new feature. Tobacco will in these areas form part of a rotation with rice, irrigated cotton and sugarcane. These practices are however quite new and further experience may perhaps bring about changes. In the older tobacco areas which depend either entirely on well irrigation or well irrigation supplementing tank irrigation tobacco follows a crop of rice or irrigated ragi. Other commercial crops like onions and garlic, sugarcane, groundnuts, turmeric and so on, are included in the rotation and the tobacco crop follows one or other of this variety of crops. In these tracts tobacco is grown in two seasons, one in the early part of the year—from January to June—and the other in the latter part of the year—October to March—on account of the ample facility available for irrigation. It is not unusual also for two crops of

tobacco to be raised in the same year on the same field or to grow a crop of tobacco every year for two or three years continuously without rotating it with any other crop. These practices should be considered exceptional; they are confined to certain villages where tobacco is the customary money crop and is never omitted whatever the difficulties may be.

Cultivation Methods.—1. *Rainfed Tobacco.*—The preparation of the field for tobacco has to be very thorough. When it is to be cultivated as a rainfed crop the fields are ploughed with the first good rains received. The ploughing is repeated with every succeeding rain. Stubble and weeds are collected and burnt and the ploughing is repeated. Not only is the field brought into very good tilth and thoroughly cleaned by these repeated ploughings but future weed growth is largely prevented so that the young tobacco will grow in almost perfect freedom from competing weeds. Prior to one of the later ploughings cattle manure is carted at the rate of 25 cartloads an acre and is ploughed in. The field is generally left in a state of fine tilth almost like blown sand, preparatory to the transplanting of the tobacco seedlings. These operations usually take from the month of May to the month of August. The various tillage operations can be carried out with improved ploughs and the bladed 'kuntes' or harrows with greater economy of labour and cost. The operations will however have to be repeated at suitable intervals as all the different weeds do not sprout at the same time and have to be destroyed as they sprout and appear above ground. Another important object of such prolonged tillage is to store up soil moisture and conserve it for the use of the crop. They are well adapted to the tracts concerned, where the bulk of the rain falls before the month of September and the last quarter of the year is one of very little rainfall followed by a period which is quite rainless and is well suited for the open air sun-curing methods in vogue for the curing of the local varieties of tobacco. As a matter of fact, the cultivation of tobacco as a rainfed crop in the Mysore State is largely confined to the western taluks of the State where the distribution of the rainfall is as described above.

Tobacco Nursery.—Simultaneously with the commencement of the tillage operations in the field the growing of a nursery has to be begun. As tobacco seedlings are transplanted when they are from six to seven weeks old the nursery has to be sown this period ahead of the transplanting and the nursery bed itself to be prepared and made ready earlier still for sowing. As individual growers cultivate only small areas of an acre or two, the nurseries are small and are generally made in the backyards of the houses or in the well enclosed stack yards close to the houses. A bed 10 feet by 15 feet will furnish enough seedlings for an acre and the required extent of nursery bed is marked out according to the area to be planted. The bed is well dug to a depth of 18

inches, stones, gravel and the roots of weeds are removed and the earth reduced to fine tilth. The bed is now laid out slightly elevated above ground level for facility of drainage of rain water, and with a low rim along the margins. The soil in the bed has to be very fine, almost like fine sand. On this dry bed dry leaves and straw are spread and the layer burnt thereon. The ashes are lightly stirred in and the bed well levelled again, and divided into three or four narrow beds by small bunds. It is now ready for sowing. The tobacco seed is exceedingly small and an ounce of it may contain some 3½ to 4 lakhs of seeds. The quantity required is therefore very small and the seeds have to be sown in such a way that they are distributed uniformly. About as much seed as will stand on a three-pie piece will give enough seedlings for an acre. The required quantity is taken and mixed thoroughly with ashes or fine soil and then scattered thinly and uniformly over the bed. It has been found that if the seeds are well dried in the sun prior to sowing the germination is much better than otherwise and this point should be noted and attended to. It may be helpful if the mixture of the seed and ashes is divided into three or four equal parts and the bed too marked into the same number of equal parts and then to sow one part of the seed mixture into each part of the seed bed. In this way an even distribution may be secured. It will be also advisable to rub the seeds before mixing them with the soil in the palm of the hand with a little kerosene oil. This will to some extent prevent the seeds from being carried away by ants from the seed beds. The soil is now lightly stirred and tamped or pressed with the hand so as to compact the surface. The bed is now thinly watered from a pot or watering can in such a way that the water soaks in without flowing over the surface of the beds and washing the seeds to one side or the other. Sand or fine soil is now strewn very thinly over the beds to cover the seeds. The bed is watered regularly once a day in the same careful manner. In five days the seeds sprout. The bed should be given a light thatch by covering it with a thin layer of straw or date leaf frond. The thatch can be removed after the seeds are well sprouted. The seedlings make rather slow progress in growth in the beginning, but once the leaves show well above the ground, growth is quick. As the seedlings have to remain in the bed for nearly a month and a half, it will be well to provide against any possible rain which may damage the bed and wash off the seedlings. A bamboo mat or '*thatti*' should be kept handy and in the event of rain this should be put over the beds supported on pegs or bricks at the sides and corners so that it lies well above and clear of the seedlings. The beds should be carefully weeded once or twice and kept regularly watered. In about forty days the plants are well grown, some six to eight inches in height and with four to six leaves. About this time they are fit for transplanting. When

tobacco is being cultivated as a rain-fed crop it may not be possible to transplant the seedlings at the correct stage on account of the lack of timely rains and the seedlings may in such cases become too old to transplant. Seedlings are in such circumstances borrowed or purchased from neighbours who may have younger nurseries and surplus seedlings. But if the area to be grown is at all large then it will be advisable to have two or even three nurseries, the second sown after the lapse of a week and the third after a fortnight from the first sowing. These nurseries are generally too small to be considered expensive and they insure one against a frequent risk.

Transplanting.—The transplanting of tobacco seedlings is taken up after there has been a good soaking rain. The field which has been prepared and kept ready by this time is now laid out for planting by means of plough furrows, ploughed lengthwise and crosswise at distances of 3′ from each other in good soils or from 2½′ from each other in ordinary soils. At the intersection of these furrows sheep or cattle manure is applied and well mixed at the rate of two large double handfuls for each pit. The tobacco seedlings which are carefully removed from the nursery, after heavily watering it to make the pulling out of the seedlings without damage easy, are brought in and transplanted in these holes at the rate of two each, or in the case of good stocky seedlings at the rate one each. The planting of two seedlings is only to guard against failure, in the belief that one at least will survive. Later on when the seedlings have established themselves, if both the seedlings survive one of them is removed. The transplanting is carried out in the evenings and if the ground is not moist enough then the pits are hand-watered. In the following morning, little leafy branches of brush wood are brought in and one is stuck in close to each seedling as a light protection against the sun. If there is no rain on the following few days, the plants are hand-watered thrice every day, for about three days, water being carted to the fields for the purpose. After the plants establish themselves interculturing is taken up. This consists in lightly stirring the soil by working a bladed hoe, with the blade turned away from the bullocks between the rows both along the length and along the breadth of the field. The later hoeing is done in the usual way and is deeper. Around the bases of the tobacco plants a certain amount of hand weeding is also done if necessary. The last interculturing is carried out by ploughing between the rows and this is repeated until the plants grow up and working with bullock implements becomes impossible. The plants grow quickly and vigorously and when they are about three or three and a half feet high they are ‘ topped ’, that is to say, the top of the main growing shoot is cut off. The plant at this stage is left with 12 to 16 good leaves. Usually the plants reach the

topping stage about 45 days from transplanting. The topping is usual in all local varieties in which large thick leaves which cure heavy are desired. The object of the topping is to divert all the nourishment to the development of the leaves and for the elaboration of the material giving the leaves their quality when cured. If the plant is left untopped then the main shoot grows normally, develops more leaves and eventually a flower stalk carrying the flowers appears, which set and ripen seed in the usual manner. The energy of the plant and the stored material in the leaves which may be required for this further growth, flowering and setting of seed is conserved and directed to the development of the leaves which are left on the plant, when topped. A plant here and a plant there are however purposely left untopped so that they may flower and set seed and meet the requirements for seed in the following year. After the plants are topped, shoots called 'suckers' begin to grow from the leaf axils quickly and vigorously and these have to be pinched off and removed. The field has to be gone over carefully and many times so that these suckers may be completely removed as they appear. The removal of the suckers is an extension of the topping and has the same object, *viz.*, to prevent the energy of the plant from being diverted to parts other than the leaves left for ripening. About the end of the third month after transplanting, the leaves become ripe enough to cut. As the leaves are not all of one age they do not ripen at one and the same time, but do so one after the other and the best method of harvesting will be to gather the leaves in three or four intervals. This is not generally done in the case of the local varieties and the harvesting is made when the bulk of the leaves is ready although some may be short of the correct stage. As the leaves ripen they become sticky to the touch due to the formation of a resin on their surface. Rain at this stage is detrimental to the quality of these leaves as it washes off this resin to a great extent. The signs of ripeness in the leaves are the formation of yellow spots here and there on the surface, a somewhat limp appearance and later the spreading of the yellow colour over the leaves.

Sun-Curing.—The method of curing the leaves in this tract of rainfed cultivation is as follows:—The plants are cut at the base and brought over the same day from the field to the village for drying. In open spaces near the village or at the side of the house the drying frames are erected. These consist of a row of jungle wood pillars about five feet high over which bamboo cross poles are tied or made to rest in the fork. The harvested plants are tied by their butt ends in two's or four's loosely and are hung astride these poles. All the plants are tied and hung up in this way. About 24 sets of such plants usually go to a six foot length of poles and a row comprises thirty feet of such sections. A cartload of leaves takes about three such rows of thirty feet each. The leaves are left on these drying frames for

one month to one month and a half. The leaves dry during the day time and become a little moist with the dew of the night. This alternation of drying and moistening is greatly esteemed and if it continues throughout the drying period the quality is very good. In the event of any unexpected rain, the rows are brought closer to each other and then covered with mats. In 40 to 45 days the leaves are dry enough to be taken down. On a dewy morning the plants are taken down, carried indoors, untied and then laid flat on the ground side by side in a square. The square is raised layer by layer until the whole lot is piled up. The pile is covered over with date mats, both top and sides, and allowed to sweat. After two days, the pile is opened and rearranged in a different place, the top layer of the first heap becoming the bottom layer of the second heap and *vice versa*. If the heat becomes too great water is sprinkled and the heap is opened out and rearranged. This process is repeated four times. The leaves are then separated from the stem, are tied up by their stalks into bunches of four leaves each and are then put up in heaps which are left uncovered. These heaps are turned over every two days until no more heat develops, which is taken as an indication of the completion of the curing. The cured leaves are now sorted and put up in bundles, and tied over with date mats, in which condition the product is ready for sale. The whole process is lengthy and laborious and requires skill and experience. From harvest to the completion of curing, the time taken is 2½ months. This method which used to be common for the production of tobacco intended for snuff-making and for chewing has in recent years been largely given up. The leaves are sold away after the drying is over and are not subjected to the curing proper. The dried leaves are broken up, put in bags and sold away to 'beedi' makers who nowadays buy nearly all the tobacco available.

Irrigated tobacco.—Where tobacco is grown under irrigation and local varieties are cultivated to be sun cured, two planting seasons are followed, one in October and another in January. In both cases the curing season falls in the rainless months. The rotations in vogue have already been described. The raising of the nursery is similar to what has been described for dry land (rainfed) tobacco cultivation. The field to be cultivated is also prepared equally thoroughly and is heavily manured. The penning of sheep is a common form of manuring in the tracts of well cultivation and a herd of 250 sheep is penned every night for a month over an acre of tobacco land. The field is ploughed once again and laid out into irrigation beds suitable for furrow irrigation. The furrows are made three feet apart. Prior to transplanting, the furrows are heavily irrigated and then the seedlings are transplanted in the furrows at distances of 18 inches to two feet from each other. The number of plants is thu much larger per acre than in dry land cultivation. In the latter

it seldom exceeds 5,000 plants whereas in irrigated cultivation it may amount to 7,000 to 10,000 plants. The operations subsequent to the transplanting are similar, such as hand weeding several times and the earthing up of the rows, which in this case is by the splitting of the ridges and converting them into furrows. Further manuring is also given, in the shape of about half a ton of 'honge' oil cake per acre, which is stirred in the irrigation water and allowed to flow in the furrows. The plants are topped and suckered in the same way. The signs of maturity in the leaves are also the same and when these are seen, which is about 3½ months from transplanting—a period somewhat longer than with dry land tobacco—the harvesting of the crop begins. Here too there is no selective gathering of the leaves, and all the plants are cut down at one harvest. The drying and curing is by a different method which is described below :—

Curing irrigated tobacco.—The plants are cut at the base and allowed to lie flat on the field itself to wilt and dry for a period of a week or ten days, the plants being turned over every morning. They lie on the field until the midribs of the leaves begin to dry. They are brought home and are arranged in the form of a square heap in the verandah ; once every other day the heap is opened and rearranged, changing the position of the plants at every such rearranging. This is repeated until the stalks are dry and lose their green colour and become quite brown. The plants are now stripped and the leaves are tied together into small bundles and put up in heaps, covered over with mats and weighted with large stones. After two days the heap is opened and rearranged and water is sprinkled if it is hot. The process is repeated until no more heat develops, which is the completion of the curing process. In some villages it is usual to cut down the plants when they are distinctly yellowing and then split them into two halves along the length of the stem. These two halves are then cut into four short lengths. Each such length will have three or four leaves together with a short length of the stem itself. These bits of the stem with their attached leaves are now strung on aloe fibre strings in lengths of about a yard and are heaped up to dry in bundles of thirty. After three days the bundles are opened, divided into two heaps and dried again ; after another three days each of these in turn is divided into two heaps and allowed to dry, and the process is finished by spreading each bunch separately to dry for three days. The drying is now complete to the degree required and the curing proper begins. The bundles are brought indoors, arranged in a square pile, covered over with mats and weighted with large stones. The pile is broken up and rearranged after two days and the process is repeated until no more heat develops. The experience and skill of the curer is trusted in all these three methods of sun curing to see that the heat of the

fermentation is just of the right degree and does not go high enough to spoil the tobacco. All of them take from $2\frac{1}{2}$ to 3 months to complete and require careful watching and close attention throughout the period. It will be seen that the process consists of two parts, one being a drying of the material to the required extent and the other the fermentation or curing proper. It is really the first one which takes the longest time, and it is in that process that local variations are much to be seen. One of these variations is the burying of the green leaves soon after harvest in a large pit and keeping it so buried for some days; a great deal of heat develops in the mass which helps to soften the tissues and the cells of the leaves very materially and thereby to hasten the process of drying in the open which follows; and the curing thereafter is very similar to the ones described already.

The colour of the tobacco in all these methods varies from brown to deep brown and very dark brown. They have all a strong penetrating smell of tobacco and taste sharply acrid. The dry land tobaccos have a better burning quality than the irrigated types which are heavy and gummy; the former are therefore purchased a good deal for the making of 'beedies'.

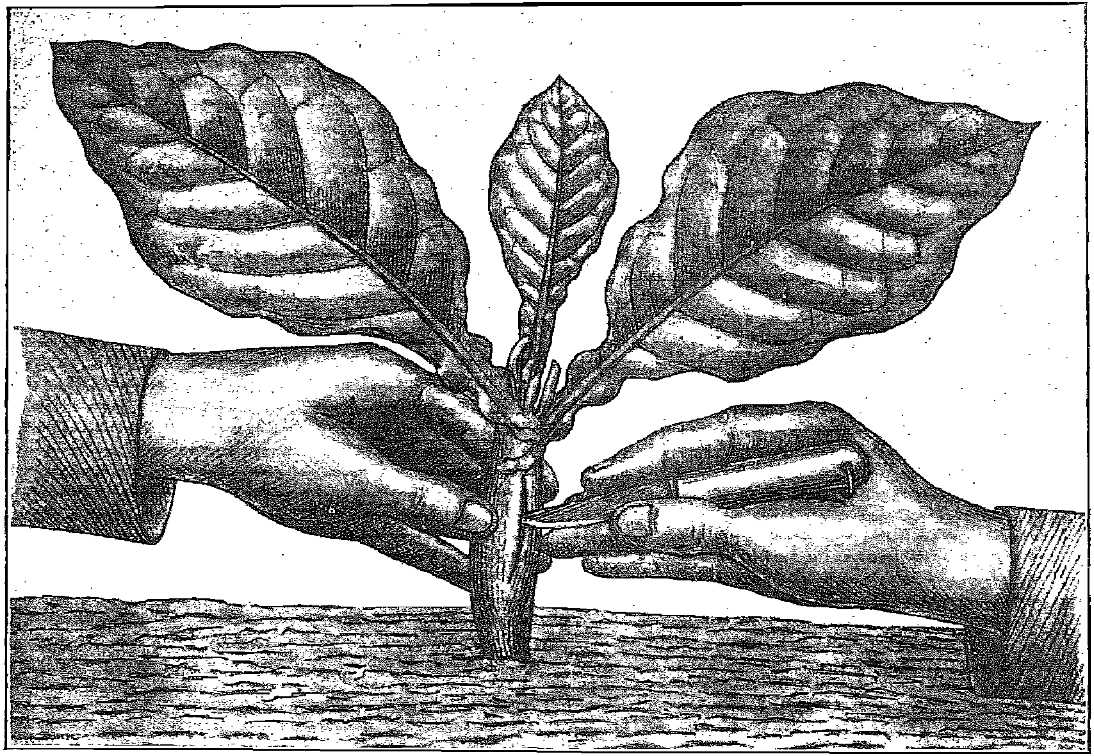
Yield.—The yield of tobacco from dry land cultivation is about 500 lb. of cured tobacco per acre in a good year but may go down very much in years of insufficient rainfall, disease and so on. On the other hand very good yields may go up to 800 lb. per acre. In irrigated tobacco the yields are very high and may go up to 2,000 to 2,500 lb. per acre and even the average may be as high as 1,500 lb.

The cultivation of cigarette tobacco.—The enormous increase in the cigarette smoking habit in recent years has created a correspondingly large demand for this type of leaf cured in the manner required for this product. The production and supply of this leaf from the U. S. A. has vastly increased and the countries within the British Empire, notably Rhodesia, have also become very large suppliers of this leaf. In India also the cultivation of this leaf and the appropriate curing methods are being taken up rapidly and over large areas and the cultivation of the local types of leaves is either shrinking in extent or is at a standstill. There is no doubt that as time goes on the cigarette tobacco will greatly increase in area and displace at a steadily increasing rate the local tobacco in many of the important tobacco growing tracts in India. The local methods of tobacco curing which have been described in the preceding paragraphs will to that extent become unimportant and obsolete, as indeed they have become already on account of the demand for the 'beedi' trade in the western taluks of Mysore. In South India the cultivation of the leaf has largely increased and new curing methods are now adopted for this leaf. The Guntur district in Madras is the most important tract; Mysore comes

next in importance where the newly started Mysore Tobacco Company operates about 10,000 acres at present which is likely to increase very much.

Though the cultivation methods are essentially the same as have been described already, there are many important features which distinguish the new variety and its cultivation. As regards curing, the method is entirely different. We shall now deal with both these aspects of the production of cigarette tobacco in South India. The variety of tobacco grown and now considered most suitable is the Virginia or yellow tobacco known as the 'Harrison's Special'. Other varieties have been grown in the earlier years of this cultivation such as Adcock and White Burley but these have now given place to Harrison's Special. This is a tall growing plant reaching some seven feet in height when it is full grown with the leaves springing some what more distant from each other than in the local varieties, which gives the plant a slightly more open look. The leaves are long and of medium width, the tips fairly pointed and giving the leaf a spindly shape. The leaves are smooth in surface and do not possess the crinkled appearance characteristic of many varieties in which the midribs and veins and their ramifications are slightly depressed below the level of the intervening leaf tissue and give the leaf surface this crinkled appearance. The leaves are also thinner and in the special method of growing (*i. e.*, untopped) become conspicuously so, as distinguished from the leaves of topped plants. A tough thin leaf, light in body, is aimed at and all methods of cultivation are adapted to this end. The soils selected are more of the sandy loam type, a purely rainfed crop (provided, of course, it does not suffer any set back from drought) is preferred, coarse and bulky cattle manure and nitrogenous manures which encourage rank leaf growth are avoided and the plants are grown without topping. Though these are the rquirements in general, a good deal of variation prevails. Thus soils of the heavier types are also cultivated with the variety, irrigation is largely practised, in fact this appears all-important under Mysore conditions, and where the plants are not luxuriant enough they are topped so as to afford greater scope for the development of the leaf. The action of rain at the last stages is not feared so much as in the case of the local tobacco. The prevalence of rain at the time of curing is not a serious trouble as the curing is by artificial heat within closed barns. For the same reason a much longer period of the year is available for the cultivation than in the case of the local tobacco. The planting is generally at distances of three feet each way. As the crop is left to grow until it flowers and as the tobacco plants are cross-fertilised in nature, the question of gathering seed has to be under strictly controlled conditions. In fact, neither the production of the seed nor the raising of the seedlings is in the hands of individual growers; in view of the great care

Field of 'Harrison's Special' Tobacco, from Goribidnur, Mysore State. [Mys. Agri. Dept.



Stem borer in young tobacco plant. Drawing shows the method of splitting the stem to remove the borer.

and technical knowledge necessary, both these branches of work are in the hands of the leaf purchasing companies which maintain a suitable organisation for the purpose.

For raising seed the fields which have plants approximating most to the type characters are selected, and among these plants the best grown ones are marked as the seed bearers. When the inflorescences are formed, the clusters are thinned to some extent, so as to reduce the number of capsules and increase the amount of nourishment for the seeds to be formed. The flower heads are now enclosed in paper bags to prevent cross-fertilisation and when in due course the seed capsules are ripe they are gathered. They are dried in the sun and then the seeds are transferred to trays, dried further thoroughly, sifted to remove particles of soil and stored in airtight tins. As it has been found that, in tobacco, heavier seeds give a better crop than lighter ones, a further selection of heavy seed is made with the aid of a special type of winnower. A blast of air is sent through the seed which carries the light seeds a longer distance; these are deposited separately and farther away from the heavier seeds. The latter of course are the seeds selected which are stored and utilised later on for sowing. Tobacco seed is remarkable for its viability. Seeds kept for ten years in suitable containers have been found to be quite good for sowing purposes.

The gathering of the leaves is also different. The plants are 'primed' at an early stage, that is to say, the lowest leaves, two to four in number, which bend down and lie with part of their length touching the ground and which are much bespattered with soil and dirt are removed and the plants are kept clean at the base. When the leaves begin to ripen, they are harvested selectively, that is, only the leaves which are in the correct stage of ripeness are gathered. The whole crop is therefore harvested five or six times as the leaves ripen. In the curing barn, therefore, only leaves of the correct and of a uniform stage of ripeness are loaded, so that they will all cure as uniformly as possible.

For raising seedlings large scale nurseries are prepared. They are selected within easy distance of wells or tanks or other good source of water supply. The soil is well prepared and elevated beds are made 3 feet broad and of any convenient length—preferably 20 yards—divided by narrow trenches one foot deep (which is the height of the beds) which serve as a small pathway. The seed bed is reduced to a fine tilth as already described and manure is applied at the rate of 1 lb. for every 4 square yards of nursery bed, and lightly stirred in. The manure is a mixture made up of 30 lb. sulphate of ammonia, 15 lb. of concentrated superphosphate of lime, and 16 lb. of sulphate of potash. The seed rate is generally 2 lb. per acre of seed bed, but in the case of good seed about half of this will be quite sufficient. In fact even this rate will make the nursery

too thick and the seedlings may become rather leggy and thin; but it is found necessary in order to make allowance for risks and loss of seed. In order to sow the seeds uniformly over the beds, the requisite quantity of seed for each bed may be stirred in water in an ordinary watering can provided with a rose and the mixture well shaken and the beds watered uniformly with this mixture. The Mysore Tobacco Company use a handy appliance resembling a small spray pump, devised and patented by one of their staff, by means of which the water and seed mixture is sprayed on to the beds, the mixture being automatically kept stirred during the spraying. The seed is then covered with a thin sprinkling of earth over which is laid a thin layer of straw. The nursery is looked after as in the case of local tobacco. Washing out by heavy rains is a contingency to provide against, and it is an investment worth while to keep bamboo mats ready for use when there is fear of heavy rain. As the seedlings grow up they have to be protected againt the moth borer, the grubs of which bore into the stem. A sharp look out is kept for the moths, and the plants are also sprayed with lead arsenate once and even twice if necessary. Seedlings of the correct age are supplied from such nurseries. Nurseries are generally sown at intervals of a fortnight, not only to meet the demand as it comes in but also to avoid a rush of leaves at harvest time beyond the capacity of the barns and to spread the harvest over a convenient period of time. Out in the growers' fields the crop receives a good dose of artificial manure mixture in addition to a basal dose of cattle manure or compost. The manure mixture applied consists of 100 lb. of groundnut oil cake, 80 lb. of sulphate of ammonia, 150 lb. of super-phosphate and 60 lb. of sulphate of potash. The young plants need attention against the stem borer. Fields have to be gone over and plants closely inspected at this stage. The presence of the borer is easily detected by a slight swelling noticed on the stem; this is carefully slit through with a sharp pointed knife and the grub is killed in its burrow or removed. Spraying is also required against fungus diseases at a later stage and spraying with Bordeaux mixture is arranged for at the proper time. These diseases are further referred to under " Pests and Diseases".

Flue curing —The curing method is quite different and is certainly an important innovation in local agriculture. The essential difference is the use of artificial heat and the production of a bright yellow coloured leaf with a very mild and attenuated odour of tobacco and the completion of the period within a week as against the two or three months required for curing the local tobacco. The method is known by the name of 'flue curing' and is carried out in specially built large rooms called 'barns' which are fitted with the necessary arrangements for a fire place, flue pipes, ventilation and so on. The barns in use in Mysore are brick built rooms with a gabled roof of zinc sheets, the

ridges of the roof being separate, elevated and adjustable for ventilation. The rooms are either 16 feet long and 16 feet wide and 18 feet high to the top of the walls or they are 20 feet square, which is now the size uniformly adopted. The barn is provided with two doorways, a glass observation window and two rows of adjustable ventilator openings along the base of the walls; when these are all shut and the ventilator ridge is let down, the barn is quite closed like a box. The heating arrangement consists of two ovens or fire places, opening and fed from outside and placed one on each side of the doorway in one of the walls; the heated gases from the oven are carried through metallic pipes or flues which traverse the entire length of the interior of the barn, are led outside, bent upwards and carried right to the top of the barn. The flue pipes are made of sheet iron of 22 gauge and are about 11 inches in diameter. Nearest to the oven the flue pipe consists of a length of six feet of cast iron piping, as sheet iron cannot stand the great heat at this place. A further protection from the great heat is also provided in the shape of a sheet of galvanised iron over the pipe. The ovens are fired either by firewood or by coal whichever may be cheaper.

The method of curing is as follows:—As the harvested leaves arrive at the barn, a rough sorting is made and poor, diseased or immature leaves are discarded. The good leaves are then tied by their leaf stalks together in bunches of three leaves and are hung astride bamboo slats and arranged side by side, the sets touching each other. The barns are provided with cross-beams in several tiers one above the other and on these the bamboo slats are placed at distances of 6 inches from each other. When the whole barn is thus loaded, it holds five tiers of leaves, the lowest tier clearing the flue pipe and hanging about five feet above the pipe. A barn of this size, *i.e.*, 20 feet by 20 feet, will hold about 75,000 to 90,000 leaves, when fully loaded. Inside the barn are also a thermometer and hygrometer, which can be moved up and down from outside by means of a string, and brought against a peep hole window for noting the temperature and humidity inside the barn. The curing process is carefully regulated by the temperature, which has therefore to be noted frequently and the firing, ventilation and so on, adjusted accordingly.

After loading the leaves, the barn is completely closed and the firing started. The temperature is raised to 90° F. and is kept at that heat for three hours, immediately after which it is quickly raised to 125° F. and held at that temperature for about half an hour. It is now reduced again to 90° F. by drawing off the fire and opening the ventilators. During this stage the barn is kept at a high humidity, the difference between the dry and wet bulb thermometers being only 3°. In this stage the leaves sweat and give off moisture profusely and the colour changes to the

required yellow tint. The next stage is to fix this yellow colour. The temperature is now raised gradually from 90° to 120° again, the rate of rise being very slow, at about 1° or 2° per hour. If the rise is rapid it is slowed down by opening the ventilators and letting in cold air. Moisture often collects over the leaves in patches and causes 'sponging' or a brown discoloration. This should be prevented, by expelling the moisture freely. This stage is referred to as 'fixing the colour' and takes about 30 hours. Air is allowed freely in through the ventilators all the time. At the end of this stage the leaf is cured. The temperature is now raised still higher and kept at a range of 140° to 170° for a period of twenty hours, during which the leaf stalks and midribs also become quite dry and the curing is finished. The whole process takes about five to six days to complete.

A variation of the above method which gives good results is the following:—First raise the temperature quickly to 90° and hold at that temperature for about eight hours, all the ventilators being shut. After this period, raise the temperature to 95° at the rate of 2½° per hour and hold at that temperature, with all ventilators shut, until the lowest two tiers are definitely yellow. Now raise it to 100° during another two hours and hold at that temperature until the third and fourth tiers are nearly yellow. Open the top ventilators only and maintain the 100° until the third and fourth tiers are definitely yellow. At this stage the bottom ventilators should be opened also, without allowing the temperature to go down. The next step is to raise the temperature to 115° gradually, increasing the ventilation through the bottom. The temperature is held at 115° until all the tiers are yellow. At every one of the different stages much care and watchfulness are required in order to be able to cope with the changes in the weather, in the quality of the leaf and so on, which may all make it necessary to effect slight changes from the routine. Though the personal element is largely reduced by the use of the thermometer to control the different stages, still a great deal of experience is required to carry out the processes satisfactorily.

The cured leaf which usually amounts to about 16 per cent by weight of the green leaves is now brought to the grading stations where it is sorted into a number of different qualities according to definite grades. The main feature of the grading is the thoroughness and depth of the yellow colour. The better, more uniform and thorough it is all over the leaf surface including the midribs and veins the higher it is classed. In fact, if it is a question of grading by awarding marks, this feature may be said to carry 50 per cent. Conversely the presence of green is penalised to the extent that the yellow is esteemed. The green and the greenish tints greatly detract from the quality of the leaf and, as faults, may be deemed the worst. Size, condition of leaf, freedom from holes, rents and spots are taken into consideration

in arranging the grades but these are much subordinate to the depth and uniformity of the yellow colour. As an example the following grade specifications of the Mysore Tobacco Company will be found instructive :—

Grade I. Lemon yellow or orange with no sponging or spots. Very slight or a trace of greenishness at the veins is allowed, as this greenness disappears in a few days.
Grade II. The same as above with very slight blemish such as sponging.
Grade III. Yellow, slightly sponged, say up to 20 per cent.
Grade IV. Bright yellow, but slightly greenish between the veins.
Grade V. Same as III but more sponged and slightly brownish.
Grade VI. Brownish yellow due to sponging, etc.
Grade VII. Dark brown like country tobacco.
I. C. X. Bright green and yellow in patches.
Dark Green. Green all over without yellow patches.

Before the leaves are exported, they are first stripped, *i.e.*, the leaf stalk and the midrib are carefully separated from the leaf blade and removed. The two halves of the leaf blade which alone are taken are all collected and are subjected to 'reconditioning', that is to say, they are treated in such a way as to contain a definite percentage of moisture. For this purpose the leaves are dried in successive drying chambers and deprived of all moisture, so that they are left as practically 'dry matter'; they are then made to absorb a definite quantity of moisture, so as to have a uniform moisture content of about 10 per cent. In this condition the tobacco is packed in boxes or hogsheds and shipped.

Botany and varieties.—The tobacco plant—Nicotiana tabacum—belongs to the natural order Solanaceæ, to which other important crops like the potato, chillies and brinjals belong. The plant is named after the Frenchman, Jean Nicot, who was French ambassador to Portugal and who in the year 1559 sent some seeds to his sovereign Catherine de Medici and also tried to popularise the plant by various other means. The cultivated plant has a straight stem and attains a height of six to eight feet. The stem is cylindrical in shape and is filled with a core of pith which on drying makes the stem appear hollow. In well grown plants the stem is fairly stout and has a girth of about 4 inches at the base. The plant has a long and strong tap root going as deep as 2 to 2½ feet and branching horizontal roots with a lateral range of about 3 feet radially from the stem. The leaves are simple and entire with a smooth margin, the internodes are long or short according to variety. The leaves

are very large, narrow and almost tapering at the petiole, thick and dark green in colour with prominent midribs and veins, and oblong, ovate or broadly lanceolate in shape. The size of the leaves becomes smaller towards the top of the plants, the lower leaves being strikingly large. The leaves spring from the stem alternately and spirally, the ninth in order being directly over the first. The leaf blade is almost horizontal and the farther half bends gracefully with the tip pointing downwards. The leaves spring from the stem either at very short intervals or at long intervals of space, which may vary from 2 inches to 6 inches according to variety and which give the plants a crowded or a loose appearance, according as the interval is short or long. Likewise differences exist in the size of the leaves and in their shape, especially in the length as related to the width, which give rise to ovate, lanceolate, broadly spindle shaped, or oblong, in form. Both stem and leaves are viscidly pubescent and as the plants grow up, these become very sticky to the touch due to the exudation of a resin. The tobacco flowers are borne at the end of the main stem and from the branches springing from the axils of the top leaves; they are in large and showy clusters. The flowers are tubular, light red, white or light pink in colour. There are also ornamental varieties which have a greater variety of colour and which are also mildly fragrant. The stamens are five in number, and are inserted in the tube of the five-lobed corolla to which they adhere at the base. The flowers are bisexual. The stigma is bi-fid and the ovary two-celled. The fruit is a capsule, and when ripe opens in two valves to shed the seeds. The seeds are excessively minute and numerous, and the embryo occupies the centre, being embedded in the endosperm.

Though the species under cultivation throughout the world is mostly the 'tabacum', there are also other species under cultivation, which occupy comparatively smaller areas. These are (1) Nicotiana rustica, a hardy species found growing wild in Mexico and which is much cultivated in Europe and in Upper India. It has ovate leaves with long leaf stalks and dull greenish yellow flowers. In northern India including many parts of Bengal it is a favorite variety, and is grown largely. It is a strong tobacco and is greatly esteemed for country cigars and for hookahs. (2) Nicotiana Persica. This is grown in Persia and is a white flowered variety, the leaves of which on curing, have a yellowish colour and a mild flavour. There are a few other species also, which are however unimportant. The varieties of tobacco under cultivation are very large in number, although many of them though distinguished by different names in different countries or provinces may be found to be either one and the same or only slightly different. The differences consist in the size and shape of the leaves, in the habit of growth, in the period of maturity and above all in the

quality of the leaf when cured which decides the particular class tobacco for which they may be eminetly suited. Being a leaf, tobacco is greatly influenced in its composition and characteristics by (1) the constituents present in the soil on which it is grown, either naturally or added in the shape of manures or brought in by irrigation water, (2) by the climate and (3) by the methods of cultivation. Very notable changes either of improvement or deterioration in quality can be brought about as the result of these factors. Nevertheless important varietal differences do exist, in which the leaves naturally possess one or other of the desired characters.

In order to understand these differences correctly it may be helpful to explain some of the terms ordinarily used in this connection. In respect of cigar tobacco, the terms 'wrapper', 'binder' and 'filler' are used. The 'filler' is the inner part of the cigar which constitutes the cigar proper, and gives it its special smoking quality. The 'binder' is the leaf which is wrapped over this filler keeping it in shape and 'binding' it. The 'wrapper' is the leaf which forms the outer cover over the cigar which decides its distinctive appearance as regards colour, texture and smoothness of feel. All three possess, of course, high burning quality. Chewing tobacco which in India is largely used in the shape of the cured leaf itself and only in exceptional cases as prepared tobacco, is in foreign countries put up in special forms, called 'slug' tobacco, 'fine cut', 'strand' or 'spun' tobacco and so on. In regard to the quality of the leaf, the term 'body' signifies generally thickness of leaf, a heavy bodied leaf being much thicker and coarser and giving a much greater weight on curing than those lacking in 'body'. It is due to the larger accumulation of both organic and inorganic contents in the leaf, such as gums, nicotine and mineral salts. A 'topped' plant will give leaves with much more 'body' than one which is not topped, other things being equal. 'Strong' tobacco is one with a higher nicotine content than 'weak' tobacco. The nicotine content varies from 6 or 7 per cent in strong tobacco through 3½ per cent in mild tobacco down to 2 per cent in still milder leaves. Toughness and elasticity as opposed to brittleness are qualities prized in all tobacco, especially wrappers and still more in cigarettes, as long clinging shreds are possible with such leaves as against chaffy or powdery shreds in brittle leaves. The 'burning quality' is one of the most important points and is greatly influenced both by variety and by environment. If a portion of a cured leaf is touched with the glowing end of a lighted match, the burnt-in hole will continue to glow becoming wider and wider as the burn extends, if the leaf has a high burning quality. If the burning quality is poor, then the fire goes off and does not extend beyond the margin of the hole made by the glowing match end. Many of the local varieties of tobacco are very poor in this respect. Manuring with potash salts especially the

sulphate and the nitrate improves the buring quality while chlorides seriously reduce it. 'Yellow tobacco is the tobacco which on curing in the proper way has a lemon yellow colour. Nearly all varieties can be cured so as to have this colour more or less but some varieties like the large number of cigarette leaf types of the Virginia tobacco have this property to a high degree. The 'wrapper tobacco' types have broader and somewhat round shaped leaves, which have thin and less prominent midribs and fewer veins; they are also very much lighter in weight. A pound of wrapper leaf will often give 1,000 wrappers while in the ordinary kinds about 9 to 10 pounds will be required for giving the same number. The Havanahs and Sumatras are outstandingly superior as wrapper types.

The Mysore local varieties are made use of mostly as chewing tobacco, especially those grown under irrigation. In the special methods of curing adopted, the cured leaves are capable of absorbing a good deal of moisture. Merchants who stock the tobacco take advantage of this fact, water that part of the stock which is to be sold in a few days and keep it well pressed in that condition. The leaf becomes darker and gains in weight by this process. The dry land tobacco is mostly bought for use as smoking tobacco and as snuff tobacco. The varieties have all local vernacular names which are descriptive of their appearance. These are, for instance (1) Kanigalu, (oleander-like) types which have long narrow leaves. They are also called 'sooji' or needle types. (2) The Anekivi (elephant's ear) types which have very broad and large leaves like the ear lobe of the elephant (3), Balepatte (plantain leaved) type, whose leaves are also long but of medium width with a smooth shining surface. All of them cure generally dark, heavy and strong. There are also varieties distinguished by other local names, which however closely resemble one or other of the above types.

Pests and Diseases.—The tobacco crop is subject to many pests and diseases.

1. *Insect Pests.*—There are a number of insect pests which are found on tobacco to a greater or less extent but the pests of major importance are (1) thetobacco aphid, (2) the stem borer and (3) the leaf eating caterpillar.

The Tobacco Aphid.—*Myzus persicæ*, *S.* is one of the worst pests. It attacks the fine and large leaves of the growing plant, which become twisted, curly and unshapely and ill-developed and then gradually fade. The plants too are greatly weakened. The underside of the leaves is covered with myriads of these insects. The affected leaves are practically useless and the damage may sometimes be very serious. Badly infested leaves have to be removed and burnt. Relief may also be had in the case of the moderately attacked leaves by spraying them with tobacco decoction, the spray being made to cover the under side of the leaves thoroughly.

The stem borer.—Phthorimæa heliopa, L. to which reference has already been made is also a serious pest, attacking seedlings in the nursery and the young plants in the fields. The growing shoot is destroyed and the plant then begins to throw out small shoots or leaves after some time which puts back the growth and gives rise to a bushy development which is of no use. Seedlings in the nurseries are also likewise attacked and ruined and when transplanted, carry the pest with them, leading eventually to the damage described above. The borer is the grub of a thin brown moth which lays eggs on the leaf stalks. When the grubs emerge they crawl down into the axil and then into the stem. eating and burrowing into the tissue. The stem shows a swelling at the spot, which is taken advantage of to detect and destroy the grub. A small slit is made into the swelling and the grub is either killed in the process or, if alive, can be removed and destroyed. In the nurseries an effective control measure is to cover the seed beds over with a thin cloth at night to prevent egg laying by the moth. Infested seedlings should be destroyed and not used for transplanting. After the crop is harvested the stubble should be ploughed up, gathered and burnt without being left on the field for any length of time, as is often done for the sake of the small ratoon leaves.

The leaf eating caterpillar.—Prodenia litura, F. causes considerable defoliation and damage in some years. It attacks the plants both in the nursery and in the field eating up the green matter of the leaves first and later defoliating the plants seriously. The adult insect is a stout, dark moth with many white wavy markings on the upper wing. This moth lays eggs on the young leaves and the egg masses are covered with the brown hairs shed by the moth for the purpose. In this stage the egg masses are easily made out and one effective control measure is to locate and rub them off. If left unobserved or unattended to, the grubs emerge in large numbers and can be seen feeding close together. In this stage also the patch can be wiped off and the grubs destroyed. The full-grown caterpillars pupate under the plants in the soil, from which the moths eventually emerge, the whole life-cycle occupying not more than 40 days. In addition to the above control measures the crop in the nursery or field may be sprayed with lead arsenate, before much damage is done. The tobacco is also attacked by other pests, such as bugs of different kinds, grasshoppers, ground beetles and a capsule eating caterpillar, but all these are only of minor importance.

Stored tobacco in manufactured form like cigars, cigarettes, and as unmanufactured cured leaf is subject to the attack of a brown beetle, *Lasioderma serricorne, F.*, the minute grubs of which bore little holes into the product and damage it. The pest is very similar to the beetle pest of stored grains and pulses. If the attack is bad, the only way in which it can be remedied is by means of fumigation with carbon bisulphide.

2. *Fungus and Other Diseases.*—Tobacco is also subject to a number of diseases, fungus, bacterial and virus. One of the commonest diseases is mildew—*Erysiphe cichoracearum D. C.*—which appears as white or asby coloured patches on the surface of the leaves and which cause the affected parts to wilt and dry up. In addition to the reduction of the crop, the disease is the cause of serious blemish in the cured leaves which become practically worthless. The disease is favoured by damp and want of sufficient sunshine. Spraying the plants with Bordeaux mixture carried out as soon as the spots are noticed will check the disease.

By far the most serious among the fungus diseases is the leaf spot disease—*Cercospora nicotianæ Ell. and Ever.* In the ordinary methods of curing and in local tobacco the damage is not considered of very great moment but in the cigarette tobacco this damage to the leaf greatly lowers the quality. The spots appear on the well grown leaves here and there at first but later many of them may coalesce into large spots. The spots become brown and then dry up producing large holes on the leaf surface. In the earlier stage the spots may not be conspicuous and the leaves may appear sound ; but in the process of flue curing they show up rapidly when the leaves are sweating and become a permanent blemish. The conditions under which the disease appears are largely connected with the seasonal conditions during the growing period, due perhaps to rain at a particular wrong stage, but they are not well understood. The disease and the damage may be controlled to some extent, if the plants are sprayed just at the time of topping, with a colloidal copper preparation. The spray is made up of the proprietory preparation called Buizol 1 oz. and Agral $\frac{1}{16}$ oz. in one gallon of water. The spraying results in an increase of crop and a reduction in the appearance of spots in flue curing.

Another serious disease which fortunately is not common in Mysore is the *bacterial wilt*, already described under potatoes. It is a dangerous disease and capable of causing great damage as it spreads rapidly and kills out the plants completely. As already mentioned it also infects the soil badly, making it impossible to grow tobacco on it in the succeeding year or years. As the soil is infected by crops of other solanaceous plants also, notably potatoes, which are largely subject to this disease, one method of prevention is not to grow tobacco following a crop of these plants nor to grow it in the same field when once the tobacco crop itself has become infected.

Tobacco is subject to another serious disease, *viz.*, *mosaic*, which is regarded as being caused by a virus. The most striking characteristic of the disease is the changed appearance of the leaves. Instead of a uniform green colour, the leaf surface shows dark green and light green in a mingled or mosaic pattern ; further, instead of the smooth surface the leaves show a very

uneven and rough surface made up of patches of thickened irregular areas which bulge upwards like small bubbles; the leaves are also curled and crumpled and greatly diminished in size. These and other malformations are characteristic signs of the disease. In advanced stages the mottling becomes very marked, and some of the patches become almost white. Not only is the yield greatly reduced but the affected leaves are almost of no value, aroma, burning quality and texture all being affected seriously. The disease is very contagious and even traces of the diseased tissue are virulently powerful in communicating the disease. Healthy plants are infected by contact with the hands or persons of the coolies working in the fields who may have handled diseased plants, by insect vectors and by contact of roots or above ground parts. There are no remedies known. Fields should be inspected from the very outset and young plants, if any, showing incipient disease should be pulled out and burnt; all contact of healthy plants with plant and other material likely to carry infection should be avoided. Seed should be gathered only from healthy plants. None of these above methods are really satisfactory in keeping out the disease, and relief can be looked for only along the lines of breeding resistant varieties. There is no doubt resistant varieties do exist in nature; even among cultivated varieties there is marked difference in the degree of susceptibilty, which indicates that the breeding out of the susceptiblity cannot be impossible.

Orobanche.—A parasitic weed—Orobanche—is one of the troublesome pests of tobacco. There are several genera and species of the *Orobanchaceae* but in Mysore the species concerned is the *Orobanche aegyptiaca.* The parasite grows in association with the tobacco plant attaching itself to the tobacco roots, and is seen above ground only when it begins to flower. The flower stalk springs close to the tobacco plant, is almost white in colour, the stalk somewhat resembling an asparagus. The affected tobacco plants become weak, cease to develop large leaves and remain stunted; in badly infested tracts the crop does not amount to much at all. The seeds of the orobanche are very fine, even smaller than the tobacco seed, with which it can mix without being detected at all. Where tobacco is grown on the field year after year the attack becomes serious. One method of control is to systematically pull out the weed as it makes its appearance above ground and thereby to prevent it from flowering and setting seed. The work must be very thorough and should be carried out several times as the weeds do not all appear simultaneously. The seed retains its germinating capacity for many years—for seven to eight years; the ordinary rotations of dry or semi-irrigated garden crops are therefore seldom found effective in killing out the pest. Where tobacco is grown under irrigation and plenty of water is available, a rice crop following the tobacco is found an effective

method of preventing it from appearing again. There should of course be no possibility of the pest being introduced again with tobacco seed; these should be collected from fields which were quite free from the pest. For the affected growing crop itself, a quick acting stimulating manure like sulphate of ammonia or nitrate of potash or soda may be given as a light top-dressing to increase the vigor of the plant and enable it to resist the attack; the relief however may not be striking, in any case it is useless from the point of view of eradicating the pest.

Chemical Composition and Uses.—The chief ingredient which gives tobacco its distinctive properties is 'nicotine', an alkaloid which occurs in the leaf in combination with the vegetable acids, malic and citric. The alkaloid is a virulent poison acting mainly on the nerve centres and paralysing them. In pure condition it is a colourless oily liquid, burning to the taste, highly poisonous and with a stupefying odour. The nicotine content of tobacco varies in different kinds of manufactured tobacco. Thus pipe tobacco contains from 0·5 to 0·8 per cent; cigars from 0·8 to 2·9 per cent; cigarettes about 3 per cent and chewing tobacco from 3 per cent up to even 7 per cent. The latter is said to be made even stronger for special brands by impregnation with concentrated nicotine extract. An industrial product of considerable importance is nicotine sulphate, which is prepared from tobacco for use as an insecticide.

Cured tobacco of some of the varieties of tobacco grown in in South India when analysed for nicotine were found to contain the following percentages.

Variety	Source	Nicotine value per cent
Yerumani padaku ...	Coimbatore	6·08
Kamuvakarai ...	Avanashi	4·906
Dakshnadi ...	Guntur	4·290
Oosikappal (chewing) ...	Bhavani	4·183
Perumathai (,,) ...	do	3·758
For chewing and beedi ...	Hospet	3·734
For chewing ...	Dindigul	3·409
Harrison's Special ...	Guntur	3·206
Oosikappal ...	Coimbatore	3·109
For chewing and snuff ...	Siruguppa	2·868
Do ...	Adoni	2·850
Snuff tobacco ...	Dindigul	2·746
Local (sun cured) ...	Guntur	2·672
Cheroot ...	Dindigul	2·672
Lanka (for cigar) ...	Rajahmundry	2·221
Oosikappal for country cigars. ...	Bhavani	2·147
Javari ..	Bellary	1·851

(Analysis by the Government Agricultural Chemist, Madras, quoted by Cherian and Kailasam, Madras Agricultural Journal, February 1939)

Tobacco stems and stalks also contain an appreciable quantity of nicotine amounting to ·1433 per cent and are useful for preparing tobacco decoction for insecticidal purposes.

Cured tobacco contains in addition proteids, starches, oils and mineral salts. The ash of tobacco is remarkable for the

amount of potash salts it contains. 1,000 lbs. of cured tobacco contains about 80 lbs. potash, 60 lbs. of nitrogen, 40 lbs. of lime, and 16 lbs. of phosphoric acid. The soluble part of tobacco ashes consists almost entirely of potash compounds in the form of chlorides, carbonates and caustic alkali.

Tobacco Seed Oil.—A bye-product of some importance which deserves to be exploited is the oil from Virginia tobacco seed. The seed contains from 35 to 37 per cent of oil, which has been found to be free from nicotine and fit for use as an edible oil very much like 'gingelly' oil which it resembles. It is thin, transparent, light yellow in colour, pleasant smelling and agreeable to the taste. It can be used for cooking, as an emollient, as an illuminant and for the making of soap. It is a semi-drying oil almost like, though somewhat inferior to, linseed oil and can be used as a substitute for this oil for mixing with paints. The oilcake left after the extraction of the oil has been found to be suitable for cattle feed, and for use as a manure.

The seed and the oilcake have the following composition :—

	Moisture	Crude protein	Oil (ether extractives)	Carbo-hydrates	Crude fibre	Ash
Seed	6·5	23·9	35·8	13·8	16·8	3·6
Oil cake	...	30·5	16·6	26·5	...	10·3

The seeds, oil and oilcake are all nicotine-free. The oil has the following constants :—

Specific gravity at 15·5°C	...	·912	to	·915
Refractive index at 20°C	...	1·4684	to	1·4725
Acid number	...	·39	to	·80
Saponification number	...	186	to	191
Iodine value	...	124	to	155.

It is estimated that an acre of the crop which is generally allowed to grow to seed will yield about 175 lbs. of seed. (*From the Indian Journal of Agricultural Science, Vol. XII, Part II*).

Production and Trade.—The area under tobacco cultivation in India is approximately 1¼ million acres. India is the second largest tobacco producing country in the world, ranking next to the United States of America. The provinces of Bengal and Madras each account for 20 per cent of the total Indian acreage, while Bombay, Bihar and Orissa account for 12 per cent each. The area in Mysore is comparatively small, and varies between 25,000 and 30,000 acres.

India imported in the year 1939-40 a total of 7,889,261 lbs. of raw and manufactured tobacco of the value of Rs. 8½ crores, out of which raw tobacco amounted to 6,597,566 lbs. valued about Rs. 4½ crores. The exports are steadily increasing and in 1939-40 the total of raw and manufactured tobacco which were

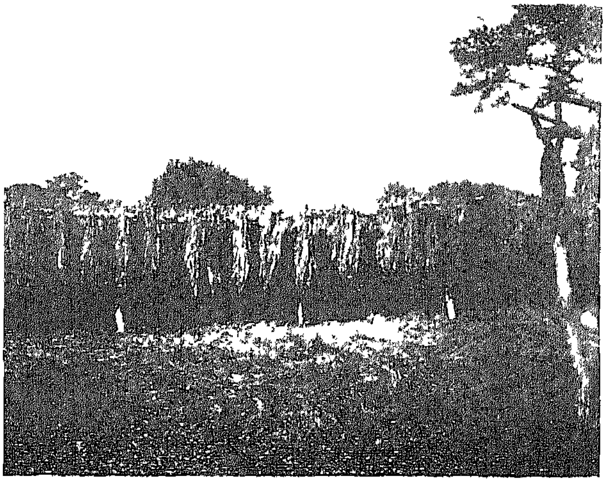
exported amounted to 52,082,289 lbs. of the value of about Rs. 2 crores. Mysore exported in the year 1938-39 about 75,000 railway maunds and imported 102,125 maunds, valued at Rs. 28 lakhs and Rs. 38 lakhs, respectively. (1 maund = $82\frac{2}{3}$ lbs.).

II COFFEE.

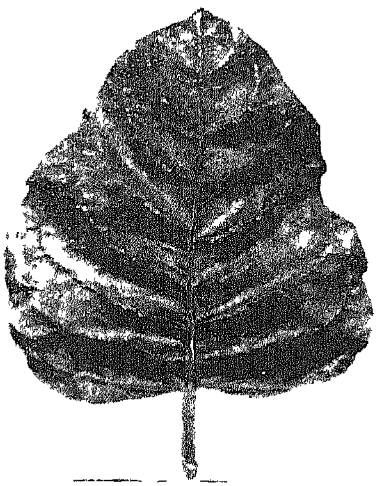
VERNACUALR NAMES FOR COFFEE: KAPEE, KOFFEE, (OR RARELY) BOON.

Distribution.—The coffee of commerce consists of the seeds of the coffee plant, which when roasted, ground and soaked in boiling water yield the fragrant, and mildly stimulating infusion used for making the well-known beverage called 'coffee'. The discovery of the use of coffee as a beverage is attributed to the Arabs, and Arabia itself is claimed as one of the homes of the coffee plant. The kingdom of Abyssinia and especially the mountainous portions of that country are also regarded as the native home of the plant. The qualities of coffee as a beverage became known to Europe through the Arabs and Turks and it is stated that the plant was introduced into that continent by the Dutch. The Dutch and the French are said to have introduced the cultivation of the plant into their possessions in South America, from where it spread into Brazil, one of the largest producing countries at the present time. The Dutch also introduced its cultivation into the Netherlands East Indies, from where it spread into the Philippines through the agency of Spain. In India, tradition has it that it was introduced by a Mahomedan saint who returned from Mecca and settled in Mysore on the hills which have since come to be known by his name, *viz.* the Bababudan Hills, and which now forms a most important tract of coffee cultivation. The cultivation of the crop now extends over many parts of the world, *viz.* Brazil, Central Venezuela, Columbia, Central America, the West Indies, Equatorial Africa especially Kenya and East Africa, Arabia, South India, Java, Sumatra and other East Indian Islands and the Philippine Islands. The limits of cultivation may be put down roughly as the 25th parallels of latitude north and south.

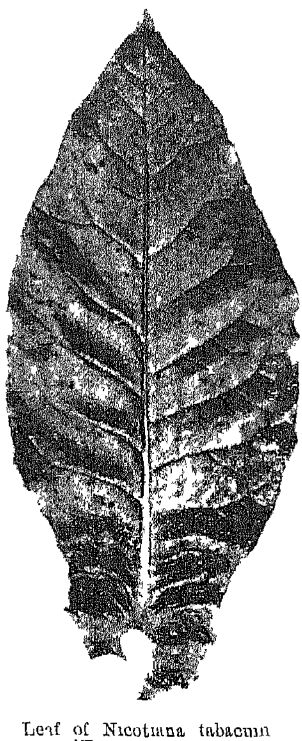
Altitude and Climate.—The coffee plant, *Coffea arabica*, which is the most important species under cultivation, grows well only on high altitudes ranging from about 2,500 feet to 5,000 feet which may be said to mark its upper limit. Other species like the 'robusta' can however be grown at low elevations, almost down to the sea level. At high altitudes like 5,000 feet and above, the cropping is late, uneven and frosts too are likely. An abundant rainfall is indispensable. A rainfall varying from 60″ up to 90″, fairly well distributed through the year with the exception of a good continuous spell of some three months



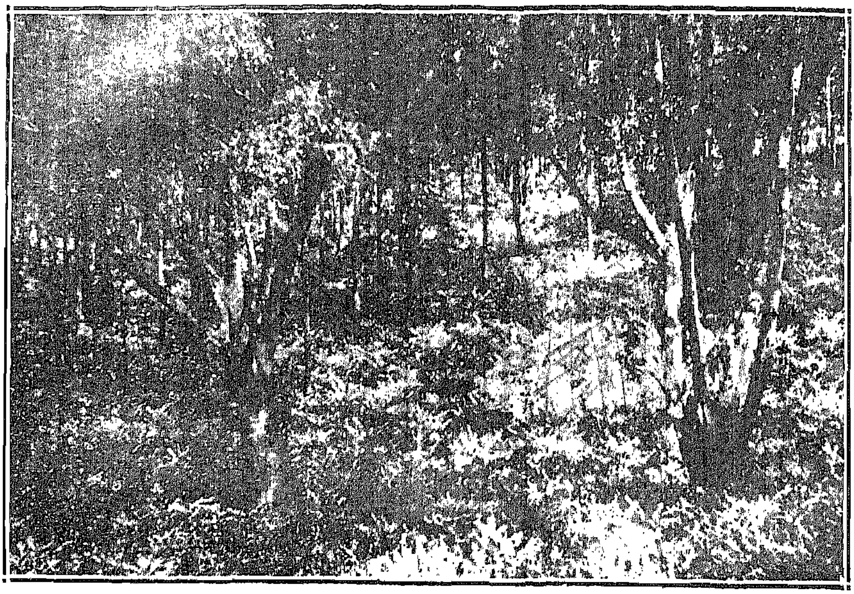
Sun-drying of local tobacco in Hunsur, Mysore State
Photo by Author



Leaf of Nicotiana rustica



Leaf of Nicotiana tabacum
(From the Report on the
Marketing of Tobacco



View of a coffee estate with the Coffee (Arabica) in bloom. [Mys. Agri. Dept.

Arabica coffee with a heavy crop, and a good leaf cover, the result of spraying.
[Mys. Agri. Dept.

following the year's harvest which will allow of the ripening of the bearing wood is necessary. Though in a high rainfall of up to 120″ coffee can be grown, the damp excessive moisture brings about considerable rot of the leaves and branches due to fungus attacks. Many attempts made in the past to grow coffee in such tracts have been failures. Failures have likewise resulted in attempts to grow it in tracts of lesser rainfall, with too many breaks, even though irrigation was provided to make up for the lack of rain. The favourable range of atmospheric temperature has the upper limit of about 80° F. and a lower limit of about 55° F. with a mean annual temperature of 70° F. Higher temperatures up to 90° F. are also common but the scorching action of the sun is generally prevented by heavy shade under which alone coffee is grown in such climates. Temperatures even below 50°F. also prevail in some coffee-growing countries, as in Brazil, but the plants withstand the cold except when frosts occur which, though rare, cause great damage when they do occur. During the greater part of the year the humidity is also high on account of the high rainfall and the considerable tree vegetation in the midst of which coffee grows.

Soils.—These climatic conditions in South India prevail only in the western parts of the Mysore plateau, in the hilly country of Coorg adjoining Mysore, and all along the spurs and sub-ranges of the Western Ghats and the similar tracts of the Eastern Ghats, embracing Wynaad, the Nilgiris, Anamalais, Palni hills, Travancore and the Shevaroy hills. The whole of the coffee grown in India is therefore confined to these tracts. The soils of these tracts are mostly derived from the disintegration of gneissic rocks and of granite in varying states of decay and vary from light ashy coloured through shades of the familiar red soils up to deep red highly ferruginous soil types. The soils over large tracts are somewhat lateritic deep red clay loams and are even markedly clayey in texture, with admixture of typical lateritic gravel. Banded hæmatites, hæmatitic quartzite, and sandstones can also be largely seen as the parent or underlying rocks from which are derived deep red soils, ferruginous soils and light grey soils, which are stiff and clayey or loose and porous or friable loams with a large admixture of the broken brittle laminated bits of rocks. The soils possess depth and fairly uniform texture, and cuttings showing up to 8 feet of such soils can often be seen. Shallow soils and boulder-strewn areas are come across only rarely in comparison. Soils of the consistence and composition of black clays and black cotton soils are seldom seen. Coffee estate soils tend generally to contain a high percentage of iron and aluminium oxide, a fairly high nitrogen content, and a low content of lime, phosphoric acid and potash. They are almost invariably acidic with a pH. value of about 4·5 and 5·5 and rarely 6. The best growth however requires that the pH. value should be high, ranging between 6 and 6·5.

Coffee soils are everywhere subject to great wash, as the hill slopes on which they lie are always steep, and frequently very steep, on which cultivation of any kind would seem impossible. There is also the tendency for an accumulation of leaf mould in the surface soils on account of the wooded nature of the slopes and the mass of fallen leaves that increases from year to year; even the highly ferruginous soils with their deep red tint are covered with surface soils which are fairly dark in colour, on account of this leaf mould.

The chemical composition of coffee estate soils may be seen from the following examples:—(All surface soils of 1' in depth).

Moisture	Nitrogen	Iron Oxide	Alumina	Lime	Potash	Phosphoric Acid	
2·3	0·178	4·54	10·8	0·70	0·26	0·06	Red soil, Hassan District.
2·1	0·19	3·6	9·8	0·28	0·23	0·068	Do
3·2	0·22	10·0	16·6	0·23	0·15	0·10	Ferruginous, Kadur Dist.
3·1	0·18	16·2	13·1	0·50	0·17	0·10	Do

Aspect.—Plantations are established generally on the sides of steep valleys, folds and gorges in the numerous spurs and off-shoots and saddles in the ghats; the open wind-swept upper slopes and hill tops are not favoured and are as far as possible avoided. The aspect of the slopes to be planted is also important, and a western aspect whether due west, south-west or north-west is not considered suited on account of the scorching action of the western sun and of the beating action of the heavy rains of the south-west monsoon in that season. A southern aspect is not bad and northern and eastern aspects are the best; a north-eastern aspect though considered also suitable has the disadvantage of rains during the picking season which may occur in some years and cause considerable loss and inconvenience.

CULTIVATION.

Clearing the Jungle.—As the coffee belt of the country is one of heavy forests on the hill sides, the starting of a plantation begins with the felling of the forest and the clearing of the jungle. At one time it used to be considered necessary to remove all the forest trees, so that later on shade trees of the right kind could be systematically planted, and special felling methods were recommended to facilitate the work. This consisted in taking up triangular sections of the forest up the slopes, partially cutting the trunks of all the trees at the base, working in this way to the apex of the triangle and thereafter in felling down completely the tree at the apex; the latter crashed, bringing down the semi-felled trees lower down, which in their turn brought down those below and so on until the whole section came down with one thunderous crash. This wholesale

felling is no longer in vogue, at any rate, for coffee. A large number of suitable trees are left standing to provide shade and only a portion is removed as well as all shrubs and smaller trees. Bamboo clad forests are however to be felled and cleared completely; as likewise low growing vegetation such as the dwarf wild date, and other jungle scrub, which is characteristic of certain tracts. In both these latter cases, the planting of shade trees has to precede the planting of coffee.

Planting Shade.—The shade trees which are selected for planting at this stage are silver oak (Grevillea robusta) and Erythrina lithosperma. The former is raised from seed and seedlings will have to be got ready and planted. The latter is raised both from seeds and from cuttings; seedlings of these will have to be ready for planting or branches from trees should be available. The silver oak is selected as a permanent shade or at any rate to remain on the ground for not less than thirty years, while the Erythrina is put down as a very quick growing tree which serves as an excellent nurse tree, as it furnishes serviceable shade in the very first year of its planting; it is looked upon as a temporary shade, to be removed after the silver oak and other shade trees have grown large enough to afford sufficient shade, though here and there Erythrinas are left as permanent shade and then grow into great specimens.

The question of shade for coffee may now be discussed briefly. Shade is considered indispensable for coffee as it is grown under Indian conditions. Shade is not a requisite for coffee universally, because in Brazil, the world's most important coffee growing country, coffee is grown without shade. In the Central American States shade is sometimes provided, but by plants which can be hardly called shade for coffee, such as, castor, plantains, papaya and so on. In Kenya where the area under coffee is rapidly expanding, coffee is grown without shade. The need in India arises partly from the severity of the hot weather which, in the absence of shade, both scorches the leaves and dries up the soil, and the coffee bushes suffer in consequence. The torrential rains of the south-west monsoon are rendered less damaging to the coffee bushes, as its force is greatly broken by the shade trees. The coolness of the shade and the heavy mulch of the leaves on the ground help the soil to retain sufficient moisture. In unshaded tracts in the planting districts such as most of the great tea estates in South India and Ceylon, the surface wash brings about such a denudation of soil, erosion of surface and even exposure of roots, that on these estates the need for shade has come to be recognised and shade trees are being systematically planted. In addition to the advantages indicated above, shade trees are found beneficial in other respects also.. The immense quantity of dry leaves which drop annually both protects the soil and improves its fertility and its physical condition. The green loppings which result from the annual shade regulation and which

are incorporated into the soil by being buried in trenches serve a similar purpose. Moreover some of the shade trees such as the Erythrina, Gliricidia, Albizzias, etc., belong to the leguminous order and should be adding considerable nitrogen taken from the air to the soil. In places with insufficient shade, the serious insect pest called coffee stem-borer increases in severity, and heavy shade reduces the incidence considerably.

On the other hand the shade tree is not without disadvantages.

The tops of the coffee bushes become choked with the fallen dry leaves which have to be removed every year. The drip in the rainy season from the leaves of the shade trees on to the coffee bushes is also damaging to the bushes. Falling branches, broken by the wind or carelessly let down in lopping, cause permanent injury to many bushes around, and where a whole tree is being removed the loss of many bushes is a much-dreaded occurrence. The roots of trees, either dead or felled and removed, are often the cause of 'stump rot' to the coffee bushes around, unless they are well trenched around and disinfected. Many shade trees sometimes harbour or start pests as host plants and the fruits of others cumber and rot on the ground or attract wild animals which prove destructive to the coffee bushes also. On the whole the balance of advantages is however in favour of the shade.

On the question as to what trees should be allowed to stand or planted for shade, individual planters may differ in their preferences, though there is a large measure of agreement in respect of most of the shade trees. The types of plants suitable for shade should satisfy more or less the following requirements. They should be evergreen, or the period of interval between the dropping of the leaves and the appearance of the new leaves should be very short. They should be small leaved, so that shade may not be heavy and massive, as it will be in the case of large-leaved trees, but such as will produce a kind of lattice effect of sunshine and shade; they should branch only several feet above ground and carry their canopy tall and spreading high above the bushes. Trees should be tough wooded so that branches do not break away in the winds. The tree roots should be deep and not surface feeders interfering with the roots of the coffee. They should, if possible, belong to the leguminous order. Very tall growing trees even with wide spreading crowns are of little value as shade. They should be quick growers, especially those planted when starting the plantations. There are also opinions regarding the harmful effects of certain trees on the coffee bushes around, and about the beneficial effects of certain others if grown in association with coffee, which should not be ignored, especially in regard to the trees believed to be harmful.

The trees usually found used for shade purposes are many species of the Ficus, Terminalia, Bischoffia, Artocarpus

integrefolia, Grevillea robusta, Albizzias, Erythrina lithosperma, Gliricidia maculata, Leucania glauca, the last three being temporary nurse shades.

The first four kinds are spreading trees furnishing moderately good shade and at the proper height. The Artocarpus gives very dense shade. The Albizzias give much chequered shade, and the species 'stipulata' with their feathery leaves is specially so, though the trunk swells to very large proportions as the tree grows old. The wood is morever brittle and branches are likely to break off in high winds. The silver oak grows very tall, is a quick grower, grows straight and pillar-like, with no crown worth speaking, shading only the bushes close to the trees and, when planted in north to south rows, the trees afford much protection against the evening sun. The Erythrinas are quick growing leguminous trees and form excellent nurse shade, somewhat thick. Likewise, but affording much less shade, is the Gliricidia, which grows somewhat low and has the further disadvantage of remaining bare for a long time after the annual leaf shedding. It can be kept headed at eight or nine feet with yearly loppings and maintained as temporary shade for a period of some ten years.

The dry leaves shed by the shade trees return back to the soil a good deal of the plant food ingredients removed by the tree, as the following analyses of the leaves of several kinds of shade trees will show.

PERCENTAGE IN AIR DRY SAMPLES.

	Nitrogen	Phosphoric Acid	Lime
Ficus mysoriensis ...	0·821	0·155	5·29
Ficus infectoria ...	0·932	0·157	5·11
Ficus (Species) ? ...	0·811	0·151	3·01
Ficus glomerata ...	0·915	0·163	5·57
Dalbergia latifolia ...	1·597	0·225	1·77
Artocarpus integrifolia ...	1·067	0·112	2·77

Planting the Shade Trees.—After the land has been cleared, the shade has to be planted one year in advance of the planting of the coffee seedlings or, if the plantations are made with a good proportion of the natural shade standing, in the same year as the coffee. Silver oaks and Erythrinas are the trees planted at this stage and they are put in rows about 12 feet apart and about 12 feet in the row. The planting is done in the month of August and the seedlings make sufficient growth in the rich virgin soil to permit the planting of coffee in September of the following

year. Later on, this distance for the shade trees will be found too close and many will have to be removed gradually so that ultimately the shade trees may be at distances of 36′ by 36′ or even 40′ by 40′.

The Coffee Nursery.—The nursery is made in a part of the estate where plenty of water may be available either from a running stream or tank and the soil is deep and rich. A suitable area of about half or quarter of an acre on this site is laid out into blocks divided by pathways. The ground in these blocks is then well dug and allowed to weather, clods are broken and the earth reduced to fine soil. Good jungle soil and leaf mould are brought in and mixed with the soil. The ground is then laid out into narrow elevated ridges about 30″ in width and 9 to 12″ in height and some 15 to 20 feet in length, and divided from each other by narrow trenches. The soil in the ridges is now manured with well-rotted and powdered cattle manure, and the surface levelled, leaving a low rim along the four margins. The whole area is provided with a protective thatch by erecting a bamboo or jungle wood frame over low posts about five feet high, and covered over with leafy twigs, dry ferns, etc. In the month of May these ridges should be ready to receive the young seedlings. These seedlings are raised separately and are transplanted in the ridges at distances of 9″ from each other and are gently watered. In these ridges the seedlings are allowed to grow until July of the following year, when the plants can be removed and put out in the permanent places in the estate. They make sufficient growth by that time, are about 9″ high and show two sets of young primaries. Nursery plants are raised also in baskets instead of in the ground as described above. Special bamboo baskets are available for this purpose and these are filled with soil of the same kind as the nursery and then the young seedlings are transplanted one in each basket. The baskets are then arranged, packed closely on the ridges fastened all round with bamboo poles to keep them from displacement and are then kept watered lightly. When the time comes for planting them in their permanent places, the baskets are transplanted to these places and are put in. Basket plants have the advantage that they can be taken long distances in the estate or elsewhere and also planted without any disturbance to the roots; on the other hand, they have the disadvantage that the condition of the roots cannot be inspected for trimming if necessary before being put in. Seedlings raised in the ground are dug up from the moist soil, as far as possible, without disturbing the roots and with the clod of earth adhering to and protecting the root system; broken or bruised roots are trimmed, a short length of the tap root also cut away and the seedlings then put in with the roots and rootlets, as far as possible, in their natural position.

The seedlings for the nursery are raised separately in seed-beds. The seeds intended for sowing in these beds are gathered

from ripe coffee fruits from selected plants. These fruits are pulped by hand; and sound beans which are uniform in size are selected; peaberry beans and beans from berries in which one grows at the expense of the other which it almost reduces to nothing in size are discarded. Though the custom at present is strictly to avoid 'peaberry' as seed, recent experiments at the Coffee Research Station, Balehonnur, Mysore, have shown that 'peaberry' can be used as seed. Plants raised from 'peaberry' grow normally and yield good crops, which contain moreover a much higher percentage of 'peaberry' beans than is usual. The beans are then rubbed with ashes to prevent them from sticking to each other, and are put out to dry in the shade. After drying they are sown thinly in a seed bed by pressing lightly each bean into the soil about ½″ deep; the bed is now kept regularly watered. In about four to five weeks the seedlings show above ground with the parchment skin still covering the cotyledons and in another fortnight, or about seven weeks from sowing, the cotyledons are open and the seedling is well above ground. At this stage the seedlings are gently removed from the moist seed beds and transplanted in the nursery beds or in baskets as already mentioned. Seed beds are sown in the months of January to March and after transplanting are available for putting down in their permanent places in the months of July to September of the following year. The sprouting of the seeds is in some places carried out in bundles of moist straw twists, until the radicles just begin to show and then put out in the seed beds to be later transplanted to the nursery beds. Germination can be hastened considerably, by sprouting the seeds in soil contained in shallow dealwood boxes, which are kept covered over with a sheet of glass during nights.

A nursery for plants suitable for shade should also be maintained in order to have seedlings in readiness for planting vacancies.

Planting.—In planting out coffee plants in their permanent places, more than one system prevails. 'Arabicas' are seldom planted wider than 7½′ × 7½′. Between these limits considerable variations can be seen, the commonest are 6′×6′ and 5′×5′. Under good management, Arabica bushes attain much bushier growth than is generally believed and can be seen to have fully covered the ground even when planted 9′×9′ or 10′×10′. For Robusta coffee the distance is much greater, being 9′×9′ or 10′×10′. The distance may be varied in accordance with the general principle that on good soils, the planting may be wider than on poor soils, and blocks and estates dealt with accordingly.

The pits for putting the plants in are made two feet in depth and about a foot in diameter; 18″ square and 18″ in depth are also usual but a 24″ depth is preferable. They are filled to the top with good jungle soil, with a small ridge all round, basin fashion. On sloping land this kind of protection is very necessary, even

though the earth around the plant may sink a little and prevent wash.

Plantings are made in the months of July to September. August will be a good month to plant, as it just clears the heavy rains and will be followed by light rains for the next three succeeding months. Some difference is sometimes made according as the nursery plants are grown in baskets or in the ground, the former being planted in September and the latter much earlier *i.e.*, in June—July, some considerable time before the onset of heavy rain. Seedlings are planted with the least disturbance to the roots which should not be freed from the basket or from the soil mass with which the seedlings are lifted from the nursery. After the plants are put in and the earth firmly tamped, the plants should be tied to thin stakes driven close to them and should also be covered with some shading material such as a leafy twig or fern.

Temporary Shade and Cover Crops.—It will be a good plan to sow a crop of tall growing green manure crop which will in the first two years shade the coffee, cover the ground between the rows, and enrich the soil; its value as quick growing shade to the coffee at this stage is however its great merit. The crops suitable for this purpose are 'Tephrosia candida' and 'Crotalaria anagyroides', the former being the more efficient. Sown thin in one row or two rows between newly planted coffee about the same time as the latter is put in, they will make a rapid growth and will be serviceable for at least two years. If necessary they can be kept up even longer, but thinned out to the extent necessary for avoiding any impediment to the growth of the coffee. During this period other temporary nurse shade like 'Erythrina lithosperma' and 'Gliricidia maculata' can be raised, and the Tephrosia, etc., then removed. The Tephrosia will largely prevent weeds from springing up and a good deal of labour in weed removal which is a large item in expenditure at this stage can be avoided.

Where Tephrosia or Crotalaria is not thought desirable owing to sufficient shade already existing, the space between the rows in the young plantation and in fact all vacant spaces among supplies in the older plantation may be sown with a leguminous cover crop which will serve the purpose of a green manure as well. The creeping or low growing leguminous crops like cowpeas, and other pulses are suitable but the best would appear to be 'Centrosema pubescens' which grows quickly, covers the ground thoroughly like a carpet and suppresses all weed growth, and lives on from year to year without a fresh sowing. Some of the 'Indigoferas' are found even better suited for this purpose than the 'Centrosema',

Manuring.—Coffee is one of the crops for which manuring with commercial fertilisers is fairly general and systematic. In the earlier days of coffee planting very high yields are said to

have been obtained even without any manuring, which is attributed to the great fertility of the virgin jungle soils. Even now, in manurial experiments, it is not at all uncommon for the unmanured plots to yield a bigger crop than the manured ones. Though manurial experiments to determine the kinds and quantities of manures to be applied and the best time for their application have been numerous, results are more or less inconclusive, a fact which is largely due to the variation in the inherent character and performance of the plants themselves which is often greater than the variation produced by manures or other treatment whose effect is attempted to be measured. Experiments free from, or designed to make allowance for, this disturbing factor are still therefore a desideratum. Some measure of agreement nevertheless prevails about the kinds and quantities of the manures to be applied, though many planters have their own ideas based more or less upon the experience in their own estates. The recommendation made herein regarding doses embody what may be called the safe principles. A basal dose of cattle manure, at the rate of about five to ten tons per annum should be given, and as there is never enough of this to be had, they are to be applied once in three or four years to as many blocks in rotation. Manuring should be complete, supplying nitrogen, phosphoric acid, and potash, and not one-sided, supplying only one or other of these ingredients The quantities of nitrogen, phosphoric acid and potash should be given in more than one form, such as oilcakes and sulphate of ammonia for nitrogen, superphosphate and bonemeal for phosphoric acid, and of sulphate and chloride of potash for potash. The year's manuring should be in two parts, one being applied before the monsoon rains, *i.e.*, about the month of March and the other part after the heavy rains, *i.e.*, in the month of September. The bulk of the nitrogenous manures should by preference be applied in the month of September, the other part being applied in the month of March, in the idea that the latter is in time for the formation of fruit and the former for the building up of new wood. The quantities of nitrogen, phosphoric acid and potash to be applied per acre are, Nitrogen 25 lbs. to 40 lbs. Phosphoric acid 45 lbs. to 64 lbs., and Potash 60 lbs. to 80 lbs. The Mysore Department of Agriculture recommends the following mixture, *viz.*, in heavily bearing areas apply 385 lbs. per annum, of a mixture made up of 150 lbs. of ground-nut oil-cake, 40 lbs. of sulphate of ammonia, 76 lbs. of concentrated superphosphate and 120 lbs. of a mixture of equal quantities of chloride and sulphate of potash; for evenly bearing areas, apply 280 lbs. of a mixture made up of 100 lbs. of ground-nut oilcake, 40 lbs. of sulphate of ammonia, 60 lbs. of concentrated superphosphate and 80 lbs. of a mixture of equal quantities of chloride and sulphate of potash. Coffee soils are, as already mentioned, low in their lime content and have a low pH value. An application of lime at the rate of one

ton of air slaked lime given once in five years, may be taken to meet the requirements in lime, ordinarily. The lime manuring is to be given only after the soil is tested for acidity, and the year's dose of the other manures should be deferred for two months after the liming, so as to avoid all risks of caustic lime acting on the sulphate of ammonia and causing loss of nitrogen. Other oilcakes like neem oilcake, or castor oilcake can be substituted for ground-nut oilcake, bonemeal (raw or steamed) substituted in part for the superphosphate, ordinary superphosphate itself can be used in the place of the concentrated superphosphate, according to the ruling prices and the convenience of obtaining them in the market. The necessary quantities required to provide the particular plant food can be easily calculated from the composition of the different manures selected. The composition of the coffee bean in respect of the plant foods is : Nitrogen—2.3%, Phosphoric Acid—0.4% and Potash—2.0%. The plant foods removed by, say, a 4 cwt. crop will therefore be about 13 lbs. of nitrogen, 3 lbs. of phosphoric acid and 12 lbs. of potash, in the cured beans alone. As however only a fraction of the manures is utilised by the crop, considerably more has to be applied than is actually removed in the shape of the crop. The special needs of the crop for producing both crop and bearing wood have also to be considered. Based upon considerations like the above, the manure dose has been fixed, as noted above.

The application of the manure is made by scattering the quantity at the base of the plants between the rows and around the bushes. The quantity per acre may be divided by the number of bushes and small tin-can measures or other receptacles made to hold this quantity, with which the manure is taken out and scattered between rows, so that the bushes may be manured uniformly. Whether the manure should be forked into the ground or otherwise stirred in, in order to mix the manure well with the soil, is a moot point. Where a heavy mulch of leaves already covers the soil as in a well filled bearing plantation, in practice nothing is to be gained by such forking and it may be dispensed with. Where the bushes are not filled and the ground is open or has a weed growth, then the manure should be forked into the ground, after the weeds are removed.

Digging and Weeding.—An expensive annual operation in the estate is the digging and weeding. Until the rows of coffee grow and close up, weed growth is very heavy in the space around the bushes, as indeed in all vacant patches, especially if the shade too should be insufficient. Cutting down of the weeds and the digging of these places is an annual operation which is generally done in the months of September to November, and again in February to March. A light digging or forking or hoeing amounting to little more than stirring the soil under the bushes even after they have closed up is advised, though it is claimed *per contra* that such a stirring is detrimental to the

young feeding roots which are immediately below the heavy mulch of dry leaves and that the mulch itself has the same effect as the stirring, which can therefore be dispensed with. A *via media* is what some planters adopt, *viz.*, to give such a digging only once in three or four years, the leaf mulch not being disturbed during this interval. In Jamaica, it is reported that planters go to the extent of growing Guinea grass for the sole purpose of being cut and brought in to be used as mulch, and that two acres of Guinea grass are grown for every acre of coffee—a fact which shows how greatly the value of the mulch is prized in that island of high class coffee.

Planting Supplies.—An important annual operation in the estates is the planting of supplies, that is to say, of young nursery plants in places where the older plants have died, been badly damaged or removed on account of borer attacks, or become too old and unthrifty. A nursery has therefore to be kept continually going as a regular part of the estate. The supply plants are put in towards the end of August. Where a good bush has only been damaged, and a complete removal may not be desirable, or the plants are poor on account of the plantation having been neglected, the bushes are renovated by the method of "stumping". In this method, the main stem is cut down a little above ground level; new suckers arise as the result, the best of them is retained and allowed to grow and managed as though it were a new plant.

Topping and Pruning.—The coffee plants if they grow normally will have four or even six pairs of primaries (the branches that start from the main stem) by March of the following year, that is, some two years from sowing the seed. At this stage, the plant is about $2\frac{1}{2}$ feet in height and it is now 'topped' by cutting off the growing end of the main stem flush with the top of primaries. If the plant has not grown well enough to attain this height, then it should be left to grow further and topped only after this height is reached. The 'topping' stimulates into growth young shoots which begin to grow vertically from near the base of the top primaries, and these shoots are to be removed systematically as they appear and the growth of only the primaries in length and thickness thereby encouraged. The removal of such shoots is spoken of as "suckering".

The growth of the plant from year to year consists of the lengthening of the primaries, the growing of the secondaries (branches starting from the primaries) and their lengthening and again of tertiaries (branches starting from the secondaries) and their lengthening and further branching. The coffee crop is borne at the nodes of the branches which are of one season's growth or one year old. The aim therefore is to induce a lengthy growth of the one year old bearing branch with as large a number of nodes as possible. The older branches serve the

purpose of foundation stock from which new branches can be started to yield a crop in the following year. Growth is however not unlimited and branches become poor bearers. A fresh sucker or new vertical shoot is then allowed to grow from near the top of the main stem and is topped in its turn above a couple of sets of primaries. This part of the plant becomes a second tier which is managed as regards pruning in the same way as the first one. In the course of time it may be necessary to raise a third tier also.

The pruning of coffee is more or less uniform and standardised in practice. The important operations are the following:—The central or upright stem having been topped at the desired height, the next growth to be attended to are the "secondaries", that is, the side branches which spring from the primaries which are the branches springing from the main upright stem. The secondaries within one foot of the main stem are cut away so as to keep the centre of the bush fairly open. The secondaries are generally the first pair to spring from the primaries and are nearest to the main stem. The next operation is to remove one secondary out of every pair of secondaries in such a way that they alternate right and left, that is to say, if the right secondary is removed in the first pair, then in the next pair the left is removed and so on. This is a kind of thinning out in a judicious manner. The next is to remove all tertiary branches as they come out. This has the object of reserving the secondaries solely for the purpose of crop bearing. Secondaries which have borne one or two crops are cut away, and the growth of new secondaries induced. Primaries which have grown too long are shortened.

Though this is roughly the general practice, much difference of opinion prevails among planters as to the extent or degree of the pruning required annually and there is therefore considerable variation in pruning ranging from 'light' to 'medium' and 'heavy'; some favour a good pruning, almost 'heavy', so as to obtain a regular though moderate yield. Others prune very little and put up with the alternate heavy and light crops.

There are other forms of pruning, and training of the plant which are however not to be seen in India. In one called the "Agobiada", for example, the main stem is bent along the ground and staked down when it is young and several suckers or upright branches are allowed to grow almost like so many different plants and are worked accordingly. Worked-out branches are removed as they become useless and are replaced by fresh suckers. Other methods are also in vogue but the system adopted in India is the "topping" method described above.

Coffee is also grown without topping at all. The world's largest production, *viz*, that of Brazil, is from bushes grown without topping. Two or three plants are planted in each hole

from which they grow into tall many-stemmed bushes, without any pruning or training and left to grow naturally. Much of the crop on the bushes is borne too high to be reached from the ground by the pickers and step ladders are largely in use for this purpose. In Mysore considerable areas of old coffee bushes raised in this way (which is called 'nati') can still be seen. The branches and suitable stems are bent down when picking the crop, sometimes the end of the bent stem is held down by the foot, both hands being thus freed for picking. New suckers are allowed to grow at intervals of a few years, and the old ones cut off.

Harvesting and Preparation of the Produce.—The coffee plant begins to bear in the third year after it is planted. It is a very moderate crop and planters advice that the flowers should be removed and only vegetative growth encouraged. Crops continue to be small until the plants are at least five years of age. From that period the bushes continue to bear and under ordinary cultivation continue to yield crops for fifty years, and even longer. It must be said however, as indeed is believed by many, that the plants at this stage are long past their economic bearing capacity and should have long been replaced by new plants. The coffee flower buds begin to form in the month of March and continue to grow in length and size and with the first heavy rains of April they swell and elongate and within a week after the rain the blossoms open. The plantation is at this time one mass of white flowers, the plants looking as if covered with snow; the bushes are alive with honey bees which feast on these flowers and help in the fertilisation. From that time onwards, with proper rains the berries begin to set and swell.

It is a great advantage to have a number of bee-hives in the estates and produce honey as a small source of income. The bees help in the fertilisation of the flowers and the setting of the fruit.

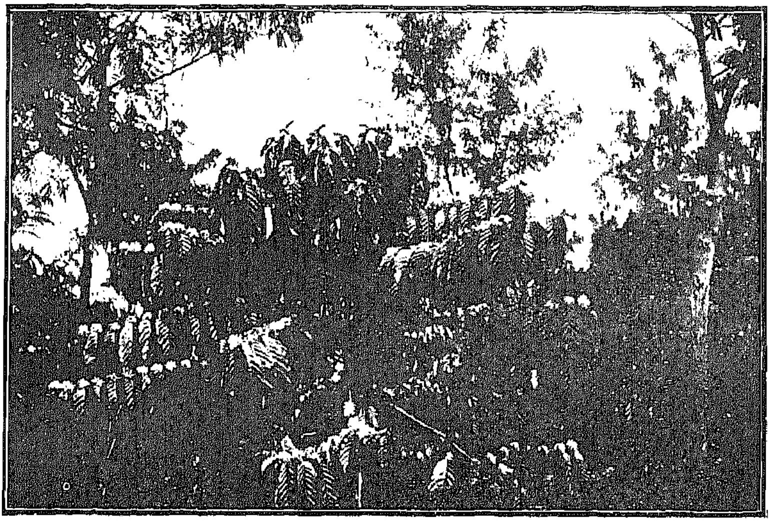
The coffee becomes ripe enough to pick from about the beginning of November when "fly picking" begins, that is, the small scale picking of somewhat stray ripe berries showing here and there on the bushes. The main picking begins later from December onwards, pickings being somewhat later on the higher elevations and colder sections than at low elevations and sunnier aspects. If there should be rain about this time, this has the effect of hastening the ripening which comes in with a rush. Picking of the ripe coffee continues well into January and then is followed by a "stripping", that is, picking of all that is left whether fully ripe or not and still later by "gleanings", that is, the gathering of all fruit that may have dropped on the ground. The main pickings are all of fruit which is well coloured and is ripe. This is the crop made use of for "parchment".

'Parchment' Coffee.—Coffee intended for the making of 'Parchment' has to be picked when ripe and fully coloured, which

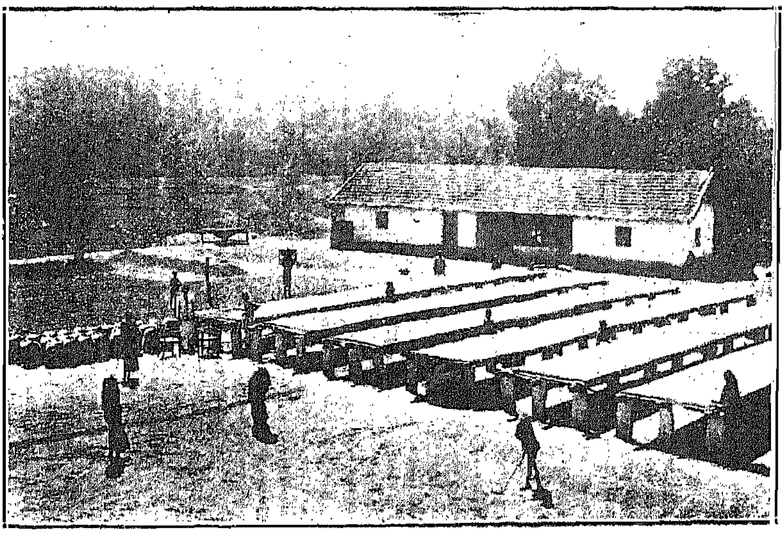
makes it necessary for picking several times in order to gather the ripe ones as they gradually become ready. In the case of "Cherry" coffee, this procedure is not necessary and the pickings need not be so many. Four rounds of picking at least are necessary for "parchment" and even as many as twelve rounds are made on high elevation estates. "Parchment" making is the method adopted on all larger estates and it requires considerable equipment by way of machinery, tanks, drying floors and mats, etc., and above all, a plentiful supply of water. The latter is arranged for from storage tanks impounding a flowing stream in the estate and situated above the pulping house to give a good running flow. The method of "parchment" making comprises the following processes :—

(1) "Pulping", *i.e.*, removing the sweet mucilaginous flesh and the skin and freeing the berries inside, (2) loosening the firmly adhering mucilage over the berries by a process of fermentation which consists in merely keeping the pulped berries heaped up, overnight or longer, (3) after thus loosening the mucilaginous coat, rubbing it out by trampling under the feet of coolies and washing the berries in repeated charges of water until the berries are quite free and clean, (4) the drying of the clean produce which now bears the name of "parchment" or "parchment coffee". Parchment is really the name given to the tough (parchment-like) coat which envelops the coffee bean at this stage.

Without going into a description of the machinery and other equipment, attention may be drawn to a few important points. Uniformity is one of the qualities aimed at in "parchment". For this purpose immature beans (which will get cut in the pulper) and light beans are as far as possible separated out, in efficient pulping houses by being floated out in the flumes carrying the berries to the pulping machine. The berries are pulped the same evening they are picked and not allowed to lie over, if this can be helped The time for fermentation is subject to variation according to the prevailing atmospheric temperature, sometimes taking only 12 hours and sometimes 36 hours (though the latter is the commonest at this picking season), and has to be stopped at the correct stage by a test washing occasionally. At the washing stage all light beans which are now easy of removal should be well separated out. The washing should be thorough so that a handful of the washed beans taken in the hand, pressed and let go, freely fall away from each other without the least sticking. Underwashing produces spots on the dried parchment and a brown stain on the bean inside the parchment, which is a blemish called "foxiness" in coffee. Overwashing on the other hand weakens the parchment and causes it to split at the drying stage. Drying is conducted over mats or on brick or cemented floors out in the sun in the open and in both cases the risk of stains on the parchment should be guarded against, as well as damage by rain.

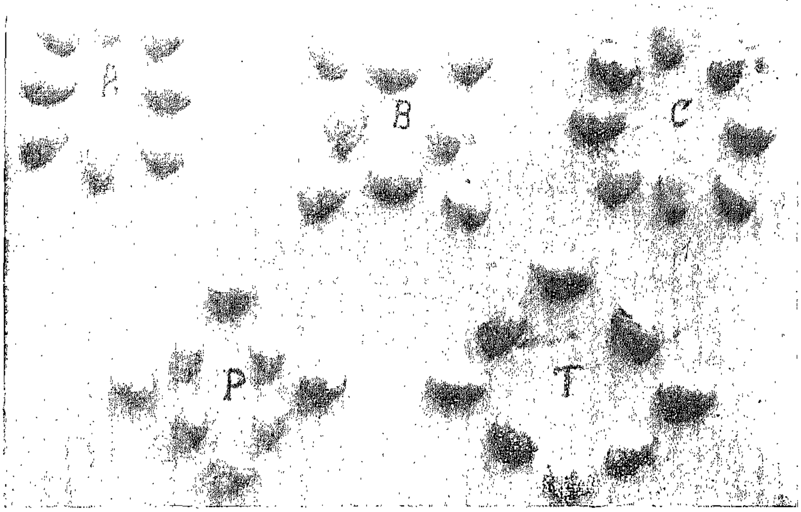


Robusta Coffee Plant in bloom. Robusta Selection, Bangelan 105, three years old.
[Mys. Agri. Dept.



Drying Coffee after pulping. Picture shows barbecues (elevated platform) and drying floor.
[Mys. Agri. Dept.

Mysore arabica.



Mysore arabica.

Grades in Coffee (Mysore *Arabica*).—

A—Grade "A". B—Grade "B". T—Grade "Triage".
C— "C". P— "Peaberry".

[Report on the Marketing of Coffee.

Seven days of good sun are considered enough to dry the produce to the correct stage; the object is not to dry it bone-dry; the stage of dryness agreed upon in practice is such that a bushel of this parchment will weigh from 30 to 32 lbs.

'Cherry' or 'Native' Coffee.—Instead of preparing 'parchment' coffee, fruits are also merely dried in the sun without any pulping at all. This is called "Cherry Coffee" or "Nat" Coffee. When coffee is grown on a small scale, say up to an area of about 25 or even 50 acres, only "Cherry" coffee is made; in large estates which make 'parchment', all the small pickings, the stripped coffee and the 'gleanings' are all simply put out to dry and "Cherry" is made. The "Cherry" comprises not only good ripe fruits, but fruits in different stages of ripeness and even unripe ones. A good drying floor is all that is needed, on which the fruits are spread and allowed to dry in the sun. Fourteen days of such drying are generally required to dry the fruits thoroughly.

Though sun-drying is the general practice in India, drying of coffee by artificial heat is also in vogue in many countries such as Java, Ceylon and Brazil. The drying is effected by heated air in special drying chambers or in drying cylinders through which the hot air is passed as they slowly rotate. It is claimed that in these drying methods which are controlled as to both temperature and ventilation, other advantages also result such as the ripening of beans not fully matured, the killing of the "stephandores" bean borer, and the bringing about of definite colour tints such as yellow or blue as may be desired.

Before the coffee can be sold it has to be 'cured'. This consists in the removal of the parchment and the silver skin in the case of parchment coffee and of the dried husks as well in the case of the cherry coffee The produce is also further dried to facilitate this removal. In small scale cultivation the cherry is generally hulled by hand pounding in the grower's household itself. The husks are thereby removed together with much of the silver skin, and by winnowing, sieving, garbling, further cleaning and separation of broken bits, and a certain amount of sorting, this coffee is ready for the market. Estate grown coffee, both parchment and cherry, is all sent out to the curing works; curing on the estates themselves is exceptional in South India though in other countries it is more general. Special hulling machinery handles the coffee in these works, by which the coffee is freed from husk and parchment and the silver skin also in part; it is at the same time sorted into the different commercial grades, and broken bits, dark beans, etc., are also removed. This clean and cured coffee is marketed in different grades. The broken bits, dark beans, etc., which are removed by hand picking (called 'garbling') form the "triage and broken bits" of the trade. Before the coffee is shipped, it may receive a further cleaning and polishing, or be shipped unpolished.

Among the malpracties in the trade is that of "bluing" coffee, that is to say, coloring it slightly blue artificially, so as to make poor coffee resemble superior coffee and pass it off as such.

Outturns of Cured Coffee.— The outturn of clean coffee from 'parchment' varies considerably from estate to estate and from year to year in the same estate. This is due to the varying proportions of light berries caused, as is generally believed, by conditions of weather, diseases, soil and differences in manuring. The outturn which is usually expressed as the number of bushels required to yield a ton of cleaned coffee, ranges from about 76 in the tracts of highly ferruginous soils, where the beans are said to be exceptionally heavy to even as low as 95. Outturns of about 82 may be considered good and about 85 an average.

Curers' statements specify, in addition, the proportions of the different grades in the lot cured. These have reference principally to the size of the bean, such size being fixed by the diameter of the aperture in the grading machine. Though in a matter of this kind one would expect a fixed standardisation, in practice there is a lack of such definiteness due apparently to machines of different makes. The following is a specimen of the statement of outturns usually furnished by curers :—

Parchment Lot 1.	888¼ bushels.		Lot II	287 bushels.
gave	123 cwts.	extra-bold O.	48 cwts.	extrabold O.
	48 ,,	A	12 ,,	A
	3 ,,	B	6 ,,	Peaberry
	19·2 ,,	Peaberry	3 ,,	Triage
	12 ,,	Triage		
Outturn, 86 bushels per ton.			Outturn, 81 bushels per ton.	

Some Technical Terms Explained.—In order to understand correctly the description of the operations carried out after the coffee is picked, an explanation of some of the terms employed will be helpful. The coffee fruit, green or ripe, is called the berry. Proceeding from the outside inwards, the various parts of the berry are (1) the outer skin, green when unripe and red when ripe, (2) the sweetish flesh called pulp and mucilaginous layer firmly adhering to the pulp, and on each seed, (3) the tough membranous skin called "parchment", (4) the thin tissue-paperlike membranous cover called the "silver skin" and (5) the two seeds, convex on the outside and flattish on the inside which are the coffee "beans," that is to say, the coffee of commerce. The groove-like depression on the flat face of the bean is called "suture." In a normal berry these two beans are equally well developed, one being exactly like the other. In some berries it happens that one bean develops at the expense of the other, with the result that one becomes very much larger than the normal bean and the other very much smaller. The latter may indeed become so small as to be reduced to a rudimentary little flat disc while its partner becomes proportionately larger, so much as to be called an "elephant" bean. In some

berries, only one seed develops which then assumes an almost rounded shape. Such beans are the so-called "Peaberry" coffee. The term 'extra-bold' 'bold' O, A, and B denote in a descending order the sizes from large to small of the cured coffee. These sizes range from 7mm for O to 6mm for C. The cured coffee is all subjected to "garbling", that is to say, broken, spotted, 'foxy,' pale, withered, 'elephants' and, small bits and stained beans are picked out by hand and the lot so separated out is called "triage." The garbling removes also what is called "blacks and bits", which include beans of which three-fourths or more of the surface is black and bits of half the size of a bean or less. "Peaberry" usually amounts to from 5 to 10 per cent of the cured coffee, and it fetches the highest price; the bold O and A comprising good sized uniform beans with a straight suture come next and the others come further down in the scale of prices. The cured coffee from the 'parchment' is spoken of as 'Plantation' as against the 'Cherry' or 'native.'

The different prices for these commercial grades generally bear the following ratio to each other. Thus if peaberry is ranked as 100, the other grades may be valued as under;—Grade O—80, Grade A—76 to 78, Grade B—66, Grade C and triage—62, Blacks, bits and browns—46.

Calendar of Operations.—The large number of operations to be carried out in a coffee plantation, most of which have been explained in the previous paragraphs, are summarised in the following calendar of operations from month to month, which is usual in estates in Mysore.

January	... Watering nurseries, picking crop, pulping and drying.
February	... Watering nurseries, picking crop, pulping and drying, digging, pruning, shade regulation, and lopping; buildings or repairs thereto.
March	... Sowing and other work in nursery, stripping and gleaning coffee, pruning, digging, cutting grass for thatching in lines, shade regulation.
April	... Pruning, digging, gleaning, repair of lines, roads and drains, manuring with phosphates and potash, pre-monsoon spraying, migrant labour departs.
May	... Finishing pruning, nursery work, filling vacancies.
June	... Cutting stumps or branches for shade, planting shade trees and stumps, filling pits for coffee, planting coffee begins.
July	... Planting coffee and shade, centring and handling coffee bushes, cutting up fallen trees.
August	... Planting coffee and shade, centring and handling coffee bushes.
September	... Post-monsoon spraying, weeding, suckering, digging, manuring with nitrogenous manure.
October	... Same as above.
November	... Same as above and preparing drying ground for coffee, fly picking.
December	... Picking coffee and pulping and drying.

Botany and Varieties.—The coffee plant belongs to the natural order Rubiaceae. Depending on the species, the plants are merely shrubs of about four feet in height, or attain a height up to ten or twelve feet or are moderate sized trees. Likewise, according to the species, the size of the stem varies from only an inch or two in diameter to stems up to nine inches or a foot in diameter. The leaves which also likewise vary in size, shape and colour are either narrow or broad, spindle shaped and pointed; they are opposite and in pairs which are 'decussate' or placed in such a way that each pair is situated crosswise over the pair above and the pair below it. The leaves are smooth and shiny and possess stipules about the petioles which coalesce into the interpetiolar type characteristic of the order. The branches are thin and whippy and spring in pairs opposite each other and decussate with the pairs above and below. The flowers are cymose clusters springing from the axils of the leaves, milk white in colour and, in the mass, highly fragrant. The calyx is small and the corolla gamopetalous, the petals being five in number. The stamens are also five and are adherent to the inner side of the tubular corolla. The ovary is inferior and is surmounted by a single bi-fid style. The corolla tube together with the adherent stamens easily breaks off at the base and can be pulled away clear of the style even in the bud stage when the latter is almost due to open. The flowers can thus be easily emasculated without injuring the stigma in any way. This makes it easy to cross-pollinate the flower under controlled conditions with any other flower which may be desired as the male parent in the course of breeding work. The coffee fruit is a two-seeded drupe which is however wrongly but commonly referred to as a berry.

Varieties Grown.—Among the many species of Coffee those in cultivation are only three, *viz.*, Coffea arabica, Coffea robusta, and Coffea excelsa (or liberica). The bulk of the world's production of coffee consists of 'arabica' and until about twenty years ago it was practically the only coffee of any importance. Coffea robusta which was introduced as a hardy species, which is largley free from the leaf disease 'Hemelia vastatrix', so destructive to 'arabica', and which can be cultivated even in low elevations on which 'arabica' will not flourish, now occupies large areas and has come into much prominence. Both in Java and in South India the area is on the increase steadily, although compared with the world's production of 'arabica', it is only of small importance. Coffea excelsa which is a variety of Coffea liberica is of still less importance.

The main characteristics which distinguish these three species and varieties grown, are as described below :—

Coffea Arabica.—The Coffea arabica is a bush about 10 to 12 feet in height with thin whippy branches growing horizontally opposite each other in pairs, and with a stem about 4″ to 5″ round. Except in Brazil, the bushes are grown pruned low to

about 4 to 5 feet and are not allowed to grow higher; the stem of these pruned bushes attains a bigger size and may be as much as 10″ round. The root system is not very profuse, but has considerable depth and lateral spread, furnishing a good anchorage and a wide feeding area. There is a strong taproot, and often a large number of axial vertical roots. The laterals turn downwards at varying distances from the trunk of the root, so that the root system is evenly disposed and deep. A few stray roots can be traced to 9 feet and sometimes 10 to 14 feet in certain tracts. The leaves are lanceolate in shape, the tip being narrow and pointed, and are about 5 to 8 inches in length and 3 to 4 inches across at their widest, and deep green in colour, smooth and glossy. In some types or varieties of 'arabica', the young leaves are light brown or copper-coloured changing to green as they grow older. The varieties show differences in the habit of growth of the primary branches, which sometimes grow straight outwards horizontally, and sometimes, especially when the plants are young, grow upwards at an angle of about 45°, and in other cases grow outwards and bend down and outwards again, thereby completely walling in the stem. Under normal conditions of rainfall, the blossoms open about the same time in the month of April and the berries ripen also equally uniformly about December. The fruits are borne in clusters at the leaf axils of one year old wood, containing from 15 to 20 berries per cluster. As the berries ripen, they change colour and become coral red when they are quite ripe. In one variety however (the 'golden drop') the fruits are a little larger and are of a deep orange shade rather pretty to look at. The beans are of a fair size and quite comparable with the size of the berry itself. The flavour is typical and is deemed superior to the other species, although varieties, soil and climate cause differences in quality to which reference will be made later on.

The species is subject to the leaf disease *Hemelia Vastatrix*, though some varieties appear to be resistant. The species can be cultivated only at higher elevations from about 2,500 feet to 5,000 feet.

Many varieties and strains in 'C. arabica' have attained considerable importance in South India and elsewhere. A most noteworthy one among these is called Kent's coffee. The strain is a vigorous grower, somewhat resistant to leaf disease, and gives a good yield with bold good sized beans. Those called 'Coorgs' and 'Chicks' are among the old favourites, popular to this day. The famous 'Blue Mountain' Coffee of Jamaica, which is the highest priced coffee in the market, is a heavy bean with a bluish colour excelling all others in quality. The variety 'Marigogipe' is noteworthy on account of its very large beans, sometimes referred to as 'elephantine'. The 'Amerillo' or 'Golden Drop' coffee gives berries which turn orange red when ripe instead of the coral red of ordinary coffee. All these

can be seen here and there as small scale introductions in South India. There are again the so-called hybrids, many of which are seen in cultivation among the ordinary coffee. These are characterised by a bushy growth and freedom from leaf disease; but they are uncertain bearers on account of the malformation in their floral organs which makes them sterile in whole or part. Two among these however are free from these defects and have gained some popularity. These are known as Netrakonda or Brown's hybrid and Jackson's hybrid.

Coffea Robusta.—'Coffea robusta' is markedly different from 'Coffea arabica' having longer branches and a more bushy habit of growth, with longer and broader leaves and a very large number of berries in the clusters. Like 'Coffea arabica' it is also grown pruned but it attains as ordinarily grown a considerably greater height of about six to eight feet. The leaves show great variation in shape and colour but in all cases are much larger than in 'arabica', being 9 to 12 inches in length and about four to five inches across the middle which is the widest part. The midribs and veins are slightly sunk and the leaf surface presents a rough and somewhat corrugated appearance. In some types the leaves are smooth and in some the midrib is elevated and the two halves of the leaf blade slope away downwards. The young leaves in all types and all the leaves, including the older leaves, in some are copper-coloured; probably these obvious differences correspond to differences in yield, quality and so on. All the flowers do not open about the same time and the picking season is later than January and is spread out also longer. The more luxuriant growth yields longer branches with more numerous bearing nodes and the clusters are strikingly large. Berries numbering from 25 to 50 can be counted in each cluster. The berries are however smaller than in 'arabica'. They change colour to a light red when ripe and yield beans which are considerably smaller than the 'arabica' bean. 'Coffea robusta' is however immune to leaf disease and to the stem borer but is subject to a shot-hole borer which attacks the primary branches and kills them. The species is adapted to much lower elevations than 'arabica' and can be grown even at sea level and on light sandy loams also. Many abandoned 'arabica' estates where 'arabica' has been killed out and 'supplies' will not take, have been planted up with 'robusta' which flourishes quite well.

Coffea Excelsa.—'*Coffea excelsa*', also called Liberian coffee or *Coffea liberica*, is a tree of moderate height attaining about 25 feet. It is grown as such and not pruned like the 'arabica' or the 'robusta.' Its tree trunk is fairly large reaching about 15 to 20 inches in girth. The leaves are strikingly different from the other species, being ovoid in shape about 6" to 7" long and 4" broad. They are thick and leathery, somewhat dull pale green in colour. The young leaves are shiny and copper-coloured but the older ones are of a much deeper tint, almost dark. The berries are

much larger and are borne both in the leaf axils and in the bare branches in singles or in clusters of two or three as in some 'ficus' trees. They have to be picked by climbing the trees. The beans are small but the quality is said to be good. The trees are however hardy and the species suits poor soils also.

Many other varieties are to be seen which show marked differences from each other. A notable one among these is called 'Abeokutæ' whose berries have sharply striped red and yellow skin, smaller than the 'liberica' but with a superior flavour and taste.

'Coffea congensis' is another noteworthy species, the berry of which resembles 'Coffea arabica' and the bean is attractively bluish in colour.

'Coffea eugenoides' is a very low bush with very small leaves looking very different from any of the species mentioned above. The berries are small, coral red when ripe, with the beans about half the size of 'robusta,' the quality being considered very good.

Pest and Diseases—Insect Pests of Coffee—C. arabica is subject to two major insect pests, *viz.*, the stem borer and the green bug.

The Stem-borer.—Xylotrechus quadripes, Ch. is a beetle pest which damages the coffee bush by boring and eating into the main stem of the bush, and eventually killing the bush. The weakening of the bush is however the earlier and proceeds progressively for several years before the bush is killed. The borer attacks both the main stem and larger branches. The adult is a dark brown longicorn beetle about a third of an inch in length. The beetle lays its eggs in the cracks and crevices of the stem; these hatch in about ten days and the young grubs commence boring and tunnelling in the stem, first close to the bark and later into the interior of the wood in the stem. The larval stage occupies nine months, after which they cut a passage near the bark and pupate close to this hole. In about a month the beetles emerge, fly about and begin laying eggs on the stems of other bushes situated even a long distance away.

The stem borer attacks bushes of all ages and the attacked plants have an unthrifty appearance with a number of bare or nearly bare branches, arrested growth of new branches, a general "crow's nested" top and yield a yearly diminishing crop. The stem shows a number of knot-like growths looking like the callussed-over base of a branch broken or fallen off. In advanced stages the stem though apparently sturdy, loses its firmness of hold in the soil and can be shaken and the bush easily uprooted. A large number of bushes have to be removed every year and as the pest spreads, the proportion of such plants increases with a consequent steady reduction in crop. This removal of bushes of bearing age in large numbers occasions serious loss. An attacked bush left standing is a serious menace to all coffee in the neighbourhood, as adult beetles emerge from such a bush, fly about

and lay eggs on other bushes and start ths pest in these healthy bushes. The remedies consist firstly in the systematic removal of *all* affected bushes. After removal these stems should all be promptly burned as otherwise they will harbour the pest and beetles may emerge. The second remedy which should also be adopted as part of the first one, is to prevent the deposition of the eggs by the beetles on the healthy bushes and the removal of any that may have been deposited. For this purpose, in the month of October the stems are scrubbed completely by a blunt blade or a bit of rough cocoanut fibre rope, by which process any eggs and larvæ close to the surface are knocked off and destroyed. In the alternative the stems should be swabbed with a tar distillate, of which more than one brand is available. This also has the effect of not only killing any eggs and larvæ, but of acting as a repellant to the beetles. A dense shade keeps down the pest somewhat, while insufficient shade and much light favor its increase.

The green bug (*Lecanium viride, G.*) infests the leaf surface along the midribs and sucks the juice out of the leaves arresting the growth of the leaves and drying up the branches eventually. The leaves also become covered with a sooty mould which also impedes their growth. If no remedial measures are taken up promptly the pest spreads a good deal and can kill out considerable portions of the bushes. The presence of ants in large numbers under the bushes gives an early indication of the onset of the pest. As soon as the pest is noticed all attacked bushes should be sprayed with a solution of 'honge' oil soap, made by dissolving 1 lb. of soap in 5 gallons of water. The spraying should be done as soon as possible after the rains cease (about the months of October and November) and should be repeated at intervals of fifteen days, twice or thrice until the pest disappears. In any case the spraying should stop before harvest commences.

A serious insect pest of C. arabica is the berry borer *Stephanadores hampeii.* South India is however free from this borer pest and any possible introduction from outside is guarded against by the prohibition by law of all import of raw coffee into India. It is usual in Java, where the pest prevails, to immerse all raw coffee in boiling water for a few minutes and then dry it for marketing.

A pest (though not an insect pest) of some seriousness of C. arabica is the nematode or eel-worm which infects the roots of the coffee and weakens the plants considerably, causing serious reduction in the crop yield and in the vigour of the plants. As the soil in these estates is fully infected, and the eel-worms persist in the soil even after the removal of the dead plants, it becomes impossible for supplies of C. arabica to become established or for such areas to be planted anew. The usual methods of dealing with the eel-worms are not applicable on an estate scale and the only remedy appears to be to replace C.

arabica with C. robusta, which indeed is what is being done in these infected tracts.

C. robusta, though free from any serious pest so far is subject to a 'shot' hole borer which destroys the primaries. Some planters control it by cutting out the branches, while others ignore it, with apparently no great harm resulting.

Caterpillars which eat the leaves of the shade trees get on to the coffee bushes also in some years and do considerable defoliation of the bushes. This occurs rarely.

Diseases.—The chief fungus diseases to which C. arabica is subject are three in number, *viz.*, 1. the leaf disease, *Hemelia vastatrix*, 2. blackrot of coffee (*Corticum koleroga*) and 3. die back.

The leaf disease, *Hemelia vastatrix* (also called 'leaf rust' of coffee) is the most serious and in the past was the cause of the ruin of C. arabica plantations in Ceylon and in parts of South India. The attacked leaves show numerous orange yellow circular spots, especially on the lower side, and soon drop off. The shedding of the leaves not only reduces the crop greatly but also weakens the plants and arrests the development. New growth and new leaves do appear, but these leaves also in turn become affected and as the disease persists from year to year the bushes are soon left with only dry bare branches. It is however easy to keep the disease under control by spraying with Bordeaux mixture, which is done twice a year, once before the monsoon breaks and the other after the monsoon is over, *i.e.*, in the months of April and September, respectively. The strength to use for the double spray is 2½—2½—50, *i.e.*, half the normal strength. Many spraying outfits are available for this work from a two-gallon pressure sprayer worked by one man to motor driven spray pumps. The Drake and Fletcher Head-land spraying machine is a favourite; with a gang of two men at the pump, four at the hose, and one man to agitate the mixture, it does one acre a day. A power sprayer driven by a petrol-driven engine with a gang of six men can cover three acres a day.

The "blackrot" (Corticum koleroga) attacks bushes in high elevations and tracts of very heavy rainfall. Leaves, branches and even berries begin to rot away and die. They hang on the bushes covered with the mycelium of the fungus and help to spread the disease. This disease can also be kept in check by spraying the bushes in the month of April with a normal 5—5—50 strength of Bordeaux mixture.

'Die back' of coffee, in which the branches begin to lose their leaves and slowly dry up from the tip downwards until in the course of a few years the whole plant dies, breaks out in certain estates in isolated patches from which it spreads. It is however never on any serious scale, and spraying with Bordeaux mixture in the early stages will prevent the progress of the disease and

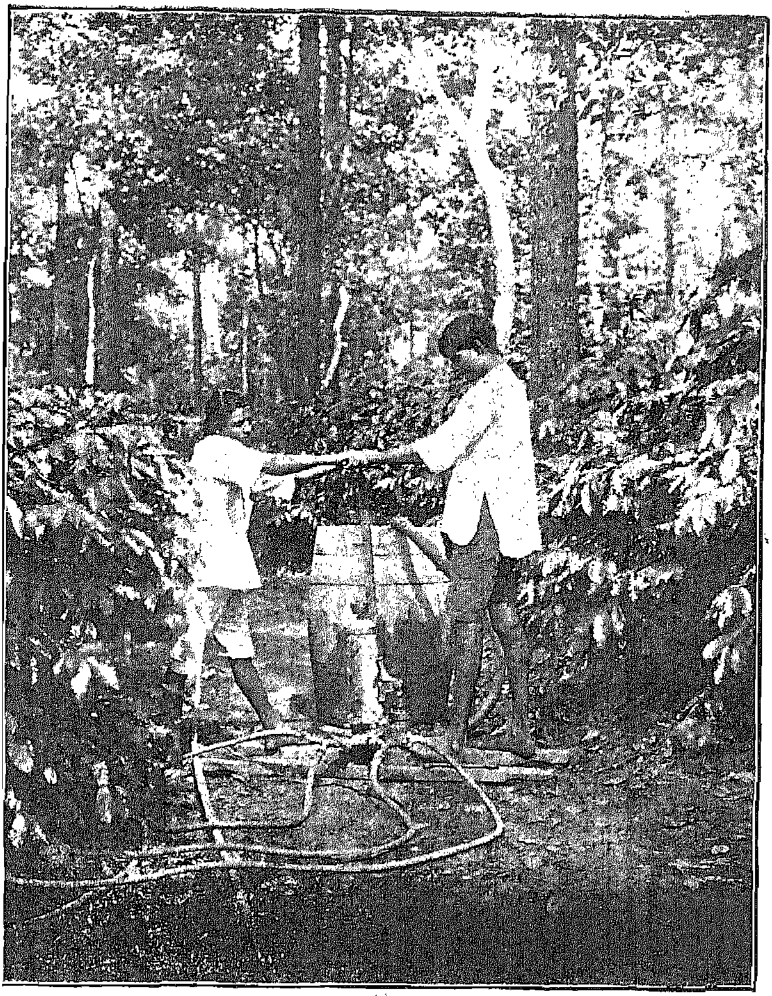
save the bushes. The spray used is the same normal strength and applied in the month of April.

A black or brown spot disease of coffee due to the fungus *Cercospora coffeicola*, attacks the leaves and berries. The latter is however the more serious as it prevents the development of the berry which shrivels in size and becomes black in colour and often drops off when immature. The disease seldom assumes importance, and can be kept in check by spraying with Bordeaux mixture.

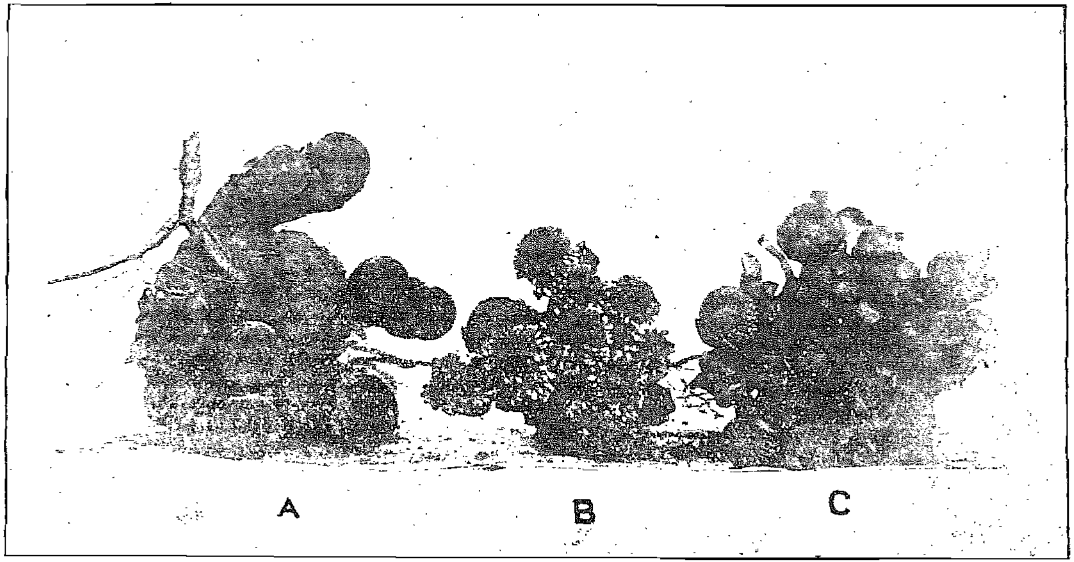
The "stump rot" is a common trouble on the coffee estate. Bushes begin to die off either in one's or two's in isolated places or in groups together. The disease is generally due to the fungus from the decaying roots of shade trees which may have been cut down and removed, or killed by 'ringing' and left standing. The roots of the dead coffee bushes are found "encrusted with a gritty mass of earth, small stones and fungus hyphae, brownish in colour, and almost of the consistency of charcoal" The remedies suggested are firstly the removal of the roots of the fallen trees, and of the dead coffee bushes, and of isolating the diseased area by means of a trench separating it from the surrounding healthy bushes.

Arabica coffee has been reported as subject to the attack of a somewhat rare vegetable parasite—a species of *Balanophora*. This is a flowering root parasite and generally impairs the vitality of the coffee bush and reduces the yield. The parasite is leafless, and occurs in the form of tuberous outgrowths on the lateral roots of the coffee. When mature the tubers look like potatoes. They now appear above ground and bear flower heads which open, are fertilised and set seed. The seeds give rise to a fresh crop when they lodge and develop on coffee roots. The remedy consists in digging out the tubers completely before the flowering begins and in destroying them. The tubers are peculiar in that they contain some 16·8 per cent oil, 11·6 per cent protein and only 4 per cent starch.

Yield of Coffee.—The yield of coffee per acre of C. arabica on estates under ordinarily good management will amount to between 2 and 3 cwts. The yield is subject of course to a great deal of variation from estate to estate depending on the situation of the estate, age and condition of the bushes and the manuring and the cultivation given and in recent years upon the spraying against leaf disease as well. The variation in this respect will range from the above figure up to as much as 10 cwts. an acre. On small exceptionally good patches a yield of even one ton an acre is said to have been obtained. At the other extreme derelict played out estates on which borers have made havoc and leaf disease has been severe, yields too low even to justify picking are also reported. It has been calculated that if each bush produces only 140 berries, this will give on the basis of 1,200 bushes per acre, a crop of one cwt. of coffee per acre—a fact



Spraying Coffee against "Leaf Disease", with a D.S.P. Sprayer.
[Mys. Agri. Dept.



A vegetable parasite (a species of Balanaphora) on the roots of Coffee. [Mys. Agri. Dept.
A. Female flowers fully developed. B. Male flowers fully developed with mealy pollen.
C. Male flowers showing *mature and* immature ones.

which strikingly indicates that even the 10 cwts. and 20 cwts. yields mentioned above cannot be called impossible of attainment.

As against the average of about 2½ cwts. of C. arabica the C. robusta yields from 4 cwts. per acre on the average with yields up to 9 cwts. an acre on good estates.

The average yields of C. arabica in other countries as compared with India are reported as below :—

Brazil 500 lbs., Columbia 600 lbs., Cósta Rica 500 lbs., Guatemala 480 lbs., and British East Africa 400 lbs., India 312 lbs.

A somewhat peculiar and disconcerting feature of coffee yields is the alternation with almost unvarying regularity of a good yield with a low yield. The following records of one estate for the period 1926 to 1935 will give an idea of the magnitude of this variation :—280, 672, 45, 390, 392, 140, 268, 84, 336, 196 lbs. per acre.

This is regarded as the natural tendency of the coffee bush to recuperate in the year following one of a heavy yield but some mitigation can be secured by adequate manuring every year. It is also claimed that judicious pruning by which a good proportion of bearing wood can be kept up regularly will also counteract the tendency to this alternation.

Quality in Coffee.—In regard to "quality" coffee is classified into two classes "Brazil" and "milds". All Brazilian coffee belongs to the first category and the coffee of the other parts of the world to the second. The "milds" have "more body, more acidity and much finer aroma" than the Brazils which are all low priced coffees. The "acidity" does not denote actual acid content but a certain characteristic sharpness of flavour. Coffees from different parts of the world have distinguishing characteristics of taste and aroma to which terms such as 'syrupy', 'winey', 'rich in body', 'spicy', 'aromatic', etc., are applied. In fixing prices "quality" is determined by a "cup" or "liquoring" test, conducted by men who by long experience can detect fine and delicate shades of difference in the taste and aroma and body of coffee. It has been found that in respect of coffees from the same tract, other things such as colour, shape and similar price-fixing factors being equal, the specific gravity of the bean is an index of the quality as denoted by the price. It has also been found that the nitrogen content of the bean runs parallel with the specific gravity of the bean and that the heavier the bean the higher the nitrogen content, so that the compactness of the bean as disclosed by the specific gravity and the nitrogen content are an index of 'quality', being directly correlated with the price. The specific gravity of the raw coffee beans in a number of samples of Mysore Coffee varied from 1·233 to 1·281 and of other South Indian Coffees from

1·202 to 1·278, with one solitary exception which was 1·178. The nitrogen content in the Mysore Coffee ranged from 2.045-2·485 per cent and in the others from 2·03 to 2·495 per cent. Work under a comprehensive scheme of research to determine if and to what extent various factors in coffee cultivation such as soils, altitudes, rainfall, manures, shade and so on influence 'quality' has been in progress for sometime in Mysore and the results should lead to some definite conclusions on this subject.

It has also been shown that 'quality' is considerably influenced at the "fermentation" stage following the pulping and that the organisms present at this stage can bring about changes in 'quality'. If, for instance, washings from admittedly high 'quality' coffee from the fermentation cisterns are added to pulped coffee known to be of low 'quality' undergoing fermentation, the resulting coffee is said to be greatly improved in 'quality'.

Chemistry of Raw and Roasted Coffee.—The characteristic content of the coffee bean to which its action on the human system as a stimulant is due, is the active principle, caffeine, the alkaloid which is also present in tea and to a smaller extent in cocoa. The percentage of caffeine is small and varies considerably between one species and another. The C. arabica and C. liberica contain in their raw beans from 1·2 per cent to 1·8 per cent of caffeine, while the C. robusta bean contains from 2·0 to 2·6 per cent. Certain species of coffee are also said to exist in which the beans are altogether caffeine-free; one such is called Madagascar coffee. The caffeine undergoes very little loss during the roasting of the bean, a rather remarkable fact when it is remembered that practically every other constituent undergoes important changes in the process. The actual flavour and aroma—the so-called 'cup' qualities—are developed only in the process of roasting, although what the exact chemical compounds are which impart these qualities is not definitely known. The roasting process brings about, among other changes, a rupture of the oil cells in the bean resulting in the escape of oil as evidenced by the oily coat on the roasted bean. There is considerable formation of gases—(mainly carbon dioxide) a product of oxidation, part of which is held in the roasted bean itself giving it its slightly puffed up appearance as compared with the raw bean. Much caramelisation also takes place which accounts for part of the aroma and which is taken advantage of when coffee substitutes such as roasted wheat and other seeds are used as adulterants. The total oil content of the raw bean varies from 12 per cent to 14 per cent and of this the volatile constituents largely escape in the process of roasting. Other changes are also known to take place and the aroma and the flavour associated with the roasted bean is the net result of all these complex changes. The composition of the roasted bean

as compared with that of the raw bean may be seen from the following :—

	Raw bean.	Roasted bean.
Moisture	8·75	3·75
Ash	4·41	4·49
Oil	12·96	13·76
Caffeine	1·87	1·81
Crude fibre	20·70	14·75
Protein	9·50	12·93
Water extract	31·11	30·30

(Analysis of Santos Coffee taken from " All About Coffee " by William H. Ukers.)

The average composition of the raw beans of Mysore Coffee is as below :—

Moisture	Proteins	Ether-extract	Crude fibre	Carbohydrates	Ash
9	13·6	12·2	19·9	33·1	9·2

The content of mineral ingredients averages as below:—

Iron and Aluminium oxides	Lime	Magnesia	Soda	Potash	Phosphoric Acid
·065	·14	3·1	·175	1·9	·39

Adulteration in Coffee.—The great popularity of coffee has led to many malpractices in the trade, such as adulteration, sale of 'faked coffee' and so on. Coffee is sold for consumption as raw coffee, roasted coffee or as powder roasted and ground. It is in the form of powder that coffee is subject to a great deal of adulteration. The substances used for adulteration are chickory root, coffee husks, various seeds such as wheat and other cereals, *Cassia tora*, tamarind seeds, mango saw dust, burnt sugar, etc. Adulteration with chickory is the commonest. It is peculiar that the presence of chickory in coffee is much liked by a section of the consuming public and under the name of 'French coffee' the coffee-chickory mixture is a recognised trade quality, which is put out and sold largely and which meets this special demand. The 'pure food' laws therefore permit such mixture with chickory, even up to a limit of 50 per cent, as in Madras and Mysore. Adulteration with the various substances mentioned and with chickory itself, if it exceeds this limit, amounts to downright cheating, and in some cases may prove even a menace to public health.

Acreages, Production and Trade.—The total area under coffee in all the coffee producing countries of the world has been undergoing a good deal of variation. Thus the areas for three five year periods from 1909 to 1934-35 was 62,84,000, acres

1,14,20,000 acres and 1,30,73,000 acres, and came down to 1,27,68,000 acres in 1936-37. Brazil accounts for nearly 70 per cent of this acreage and India for about 1½ per cent. Brazil likewise produces nearly 65 per cent of the world's production. India accounts for 0·7 per cent. One of the noteworthy features of the world's production is the fact that owing to the depression in prices as a measure of maintaining a certain minimum price level, Brazil has been destroying enormous quantities of her production every year, which amounted during the seven years ending 1937-38 to the huge total of 74,000,000 cwts., which is equivalent to India's production reckoned for 125 years.

The coffee acreage of India is about 200,000 acres, of which Mysore accounts for 50·2 per cent, Madras Presidency for 26·5 per cent and Travancore and Cochin 3·7 per cent. The total estimated production (1935-36) was 7,02,000 cwts., of which about 92,000 cwts., was exported. Since 1931 the import of raw coffee to India has been prohibited.

III. TEA.

VERNACULAR NAMES FOR TEA, *Kannada*—TEA SOPPU; *Tamil*—THEYILAI, *Hindustani*-CHA

The tea plant is cultivated for the sake of its tender leaves and leaf shoots which are manufactured into the familiar product used for preparing the world-famous and well-nigh universal beverage which goes by this name. Like coffee and rubber, the tea plant is grown in India on a large plantation scale and the cultivation is mostly in the hands of large capitalistic concerns, the estates themselves running into hundreds and sometimes even thousands of acres in extent. The conversion of the green leaf into the manufactured product has ceased to be a small scale domestic concern using simple primitive appliances and has developed into a large scale manufacturing factory process, involving the use of extensive industrial plant and machinery and adapted to the handling of the produce of hundreds of acres. This development has left little scope for any small scale cultivation, and such cultivation where it does exist is carried on only in the neighbourhood of the large estates and their factories and is devoted solely to the growing of the leaves which are sold to the factories for manufacture. Like coffee and rubber the cultivation of tea in India is highly localised, being confined to certain comparatively small tracts of country, such as the eastern corner of India in Assam and Eastern Bengal and the southern extremity of the Western Ghauts extending from Coorg to Travancore. Like coffee and rubber again tea is also a recent introduction; the cultivation on

any important scale is less than a hundred years old and can in this respect be said to be intermediate between coffee which is much older and rubber which is very recent. Unlike coffee and rubber, however, as an article of every day use tea can lay claim to great antiquity. The tea drinking habit is of Chinese origin, and in that country it is said to have been in use as a beverage from about the 8th century A.D. and as a medicinal article even much earlier. In Japan, the other important country where tea forms a national drink from ancient times, the habit is said to date from the 13th century. It was not however till some three centuries later that it was introduced into England, where it rose steadily in popularity, giving rise to a most profitable trade. This was mostly in the hands of English traders, though the supplies were all derived from China. It was not long before attempts were made made by the East India Company to wrest this monopoly from the 'celestial empire' and to grow it within their possessions in India. The cultivation of tea in India owes its origin to these attempts which, started in the year 1834, were carried out with great vigour and thoroughness and resulted in giving a substantial lead to the cultivation of the plant on a large scale.

Distribution.—The tea plant, *Camellia theifera*, is considered to be a native of Assam and the adjoning parts of Upper Burma, where it has been found growing wild. Many species and varieties are found under cultivation but the most important of these are the types variously called 'Assam indigenous' or 'Manipur indigenous' and the Chinese tea. Hybrids of various sorts between these two also form a large bulk among the cultivated types. The plant thrives under a wide range of conditions and within a very wide range of latitude, such as, for instance, from Sumatra, Java and the Dutch East Indies in the south to Japan and Manchuria in the north. The main tea-growing countries of the world lie however in the continent of Asia both in the mainland and in the islands of the Indian and Pacific oceans. India, Java, Ceylon, the Chinese Empire, Formosa, Japan, Java, Sumatra and the other islands of the East-Indian archipelago and Southern and South—Eastern Russia constitute the main, if not the sole, countries of tea cultivation. In India itself the tracts of tea cultivation are Eastern Bengal and Assam, the Kangra valley and northern U. P. in the north and the Nilgiris, Anamalais, Mysore, Wynaad and Travancore in the south.

Climate and Altitude.—In regard to the climate suited to tea cultivation, as indeed in regard to many other aspects of its cultivation, it is well to remember that the tea plant is cultivated for the sake of its tender newly formed leaves and leaf shoots, and that every factor of growth should be such as to encourage the plant to put forth copious new growth as often in the year as possible, so that pickings may be frequent, numerous and heavy, consistent with the health and permanence of the bushes.

Such conditions exist where the temperature is high enough to permit of growth throughout the year and the annual rainfall sufficiently heavy and well-distributed, so that there is practically no rainless month in the year, such as obtain, for instance, in Java, Sumatra and the East Indies, Ceylon and South Travancore. In the tropics proper and in and about the equatorial regions such conditions of temperature and rainfall obtain and the tea crop here maintains a luxuriant and continuous growth. Any long spell of dry weather such as is likely in the months from December to April and May in South India is not favourable, and so is the check or cessation of growth that may occur owing to low temperatures in the higher latitudes. A well-distributed rainfall amounting to 60 or 70 inches in the year should be considered very favourable. In the tea districts however the rainfall may go up sometimes even to 200 inches in exceptional cases in the year but these rains occur mostly in the height of the monsoons and are confined to comparatively short periods when the rains are torrential. The chief harm of such rainfall occurs in the shape of surface wash and erosion of the soils of the steep hill slopes on which the bushes are grown rather than to the tea plant itself.

The temperature in the tea districts seldom exceeds 100°F. in the hot weather and in the cold weather seldom goes below 52°F. During the heavy monsoon rains the atmosphere is exceedingly humid and fires in the dwelling houses are necessary, more however against the damp which is all-pervading than against the cold. In high latitudes where tea is cultivated, both snow and frost may occur, but the tea bush is able to withstand without injury both snow and frost of moderate severity. The only effect is a cessation of growth and dormancy with, however, no shedding of leaf or other typical winter appearance. An average temperature of about 70°F may be taken as the most favourable.

In regard to altitude, the tea plant is remarkably adaptive; the plant flourishes from almost sea-level or about 300 feet up to very high elevations of up to even 6,000 feet above sea-level. There is however a difference in quality in the tea manufactured from leaves grown in the different elevations, so much so, that 'quality' is often distinguished as, 'low elevation,' 'medium elevation' and 'high elevation', which are in the ascending order of excellence. With the exception of a great part of the tea tracts of Eastern Bengal and Assam the tea estates in India all lie at elevations ranging from 2,500 to 6,000 feet, in the slopes and hill tops, saddles and folds of the Western Ghauts and their numerous spurs, and the tea from these will be ranked as medium and high elevation in quality.

Soils.—The soils of the tea estates of South India are predominantly the red or chocolate coloured clay loams, sometimes characterised as lateritic. There is also a large percentage

of soils which are very low in clay content and should be classed as ordinary loams or even sandy loams. Tea soils from the Anamalais, the High Range and Central Travancore, belong to the latter class and contain from 5 to 7 per cent only of clay ; those from Nilgiris, Wynaad and South Travancore contain from 16 to 20 per cent of clay and should be classed as ordinary light loams. One of the best tea soils (in the High Range) had a mechanical composition as under: coarse sand 31·5, fine sand 17·8, silt 13·3, fine silt 14·7, clay 15·7, per cent. The loss on ignition was 15·7 and the plant food constituents were, nitrogen 0·31, phosphoric acid 0·13 and potash 0·30 per cent. (Dr. Shaw) The soils are generally of an open texture and easily drained. In the high elevations they are ,further, rich in organic matter derived from the debris of jungle vegetation. As against these soils there are other large stretches which should be classed as distinctly clayey. These are stiff and difficult of drainage but seldom lack in drainage on account of their situation on steep slopes. Nearly all these soils have a high iron and alumina content, are very poor in lime and phosphoric acid, but moderately rich in nitrogen. The tea soils of Assam and Eastern Bengal are comparatively richer in their plant food content, and the low level flat land soils are particularly so. The soils possessing the most natural fertility are those of the Dutch East Indies, where they are of volcanic origin and derived from recent formations. Tea soils in India have one common characteristic, *viz.*, a very low lime content. They are all acidic and their pH value is below 6·0 and often goes down to 5·4 and 5·0. It is very seldom that black clays are met with on which tea is grown, a rather striking exception being the small black soil belt in Ceylon on which (as for instance at Nuwara Eliya) very good growth of tea can be seen.

Drainage.—Though on account of the situation of most tea estates on hill slopes, the question of drainage does not arise, tea like most crops, has to be protected against insufficient drainage ; both on flat land and in extensive patches or pockets of badly drained soil even on hill slopes there is need for drainage, and suitable trenches have to be cut and the congestion of sub-soil water relieved. Drains form a prominent feature of many estates, though the main object of these is different. They are made more for preventing surface wash and soil erosion than for the removal of excess water from the sub-soil. They are cut across the slopes and generally follow the contour lines, and are made quite 18 inches to 2 feet in depth and about the same in width. Any rapid flow of water even in the drains is broken by means of low baffle mounds or walls put up across the drains, at frequent intervals or by means of 'reversing drains'. These are drains in which the floor or bottom is made in a series of sections which slope slightly upwards or against the flow, so that the water has to back up a little in each before it can run into

the next section and therefore loses in the process much of its eroding force. The wash is so great in these tracts that large bushes may be seen with the soil round their roots washed away, leaving them quite exposed to view. New gullies form and old ones are widened with amazing rapidity and an extensive system of drains is an absolute necessity for preventing this damage. As a matter of fact even in spite of such drains, considerable damage is caused which has to be repaired by revetment or other permanent arrangements.

Shade.—Where plantations are being opened on jungle land the planting of the tea has to be preceded by the clearing of the jungle. Such clearing is generally of a wholesale character; all trees and shrubs are cut and also removed from the land to the extent possible and the ground is left bare of any tree growth. Tea is also grown without any shade, in very marked contrast with coffee. The need for shade is however slowly beginning to be recognized and much change is noticeable in recent years, in this respect. The effect of shade in keeping the atmosphere cool and mitigating the drying action of the scorching heat of the summer months during which no rains occur in many tea tracts is a decided advantage, and in South India, meets a real need. A judicious retention of the natural tree growth will therefore be an advantage. If necessary, these may later on be removed and be replaced by the regular planting of any selected species of shade of any desired description. High shade is apparently not required for tea, perhaps not favourable either, if present estate practice is any guide. A low growing tree like the *Erythrina indica* or *lithosperma,* which is kept severely pollarded, is favoured where shade is considered necessary and a few *Albizzia moluccana* and *A. stipulata* trees are also planted and allowed to grow to provide tall shade. Other species which are planted are more in the nature of nurse trees or green manures and to this class belong the *Gliricidia maculata* and *Tephrosia candida* or *Bogamedalloa* which is sown thick and grown between the rows of tea.

Trees are also planted to serve as wind breaks in the very large estates especially, and in that case form rather thick belts both along the margins and in the interior of the estate itself across the direction of the wind where they serve the double purpose of shade and wind break. The most favoured tree for this purpose is the silver oak (Grevillea robusta).

Nurseries and Planting.—The planting of tea is either of germinated seeds or seedlings one year or 18 months old. The planting of seedlings is however the more general practice. In either case a nursery has to be prepared and sown, thickly in the first case to yield a large number of germinated seeds, and thinly and at regular intervals—usually 4" by 4"—in the second case. The nursery is made in a part of the estate with convenience for water; it is well prepared by deep digging, removal of

weeds, old roots, stems, etc., and laying out into narrow beds about a foot high and divided by pathways. The seeds intended for sowing must be as fresh as possible; tea seed loses its germinating capacity very soon under ordinary conditions and little time should be allowed to elapse after the seeds are gathered and before they are sown. Well dried and preserved in hermetically sealed tins, however, the seeds are known to keep for some months. The tea plant flowers from about the month of September and the seeds are ripe and ready for gathering in a year thereafter, so that sowing has to be done about the months of November and December. Moreover many tea seeds, though outwardly sound, are light and ill-developed and even quite hollow. Good heavy seeds which indicate a well developed kernel have to be sèlected for sowing. Seeds are planted two inches deep and the beds are kept watered regularly thereafter. When the seedlings show well above ground, the nursery is weeded and a light thatch or lattice-like cover is erected above it for shade. In six months the seedlings are ready for transplanting but it is usual to allow them to grow in the nursery for one year or 18 months and then only to remove them for transplanting. Pits for receiving the plants in their permanent places are made about a foot deep and about 9 inches in diameter and at distances of about 4½ feet from each other. The planting distances are however subject to a certain amount of variation depending upon the variety planted, the soil, the steepness of the slope and other circumstances. The closest planting may be taken as 5 feet by 3 or even 2½ feet and the widest planting as 6 feet into 6 feet. The 'Assam' and 'Manipur indigenous' which are vigorous and large-growing varieties and the ones now being planted generally are put in 6 feet into 6 feet. The hybrid varieties and the Chinese variety are planted closer at 4 feet into 4 feet. On poor soils and on steep slopes the planting is still closer and almost hedge-like, being 5 feet into 3 feet or 5 feet into 2½ feet. The varieties to plant are of the first type and neither hybrids nor the pure Chinese are now planted. The former types are moreover carefully isolated when they are to serve as seed bearers, so that no mixtures can arise. The pits for planting are lined either in the rectangular or the triangular system. They are filled with well-weathered jungle soil and the planting is made in the months of September, October, when the ground is moist to a considerable depth and the plants have the advantage of light rains for some weeks till they become established. Seedlings for transplanting are taken from the nursery with the ball of earth adhering closely and are then planted. The planting may also be done in the early rains preceding the S. W. monsoon, *i.e.*, in the months of April-May. When seedlings are to be transplanted without the ball of earth then their tap root is cut away where it may be bruised, the laterals well spread out and then planted.

In well-established plantations there is always a seed plot reserved in some part of the plantation, where the bushes are grown without pruning, into trees. These flower and set seed and the seeds required for the nurseries in the estate are derived from this seed plot. A nursery is always put down every year for the purpose of raising seedlings required for filling blanks or for extensions.

Plucking and Pruning.—Under ordinary care and cultivation the tea bushes become well established within a month or six weeks after planting and in the course of the first year or 18 months may attain a height of 2 to 2½ feet. After this stage the work of pruning which is undertaken for giving the desired height, branching habit and shape to the bushes commences. As the tea plant is grown for the sake of its tender shoots and young leaves and as these have to be plucked and gathered by hand it is necessary firstly that the bushes should have a large number of young branches from which the leaves can "flush" and that the bushes should be low enough for picking the leaves.

At the first pruning the plant is cut low, about 9 inches or even 6 inches from ground level, leaving at least two side branches below the cut which are themselves trimmed to a length of 15 inches to 18 inches. The growth of a number of side branches all springing low and growing outwards, so that the bush will appear as though the branches all sprang from the level of the ground, is encouraged. In the second year the pruning is repeated, the whole of the bush including the main stem and all the branches being cut at a uniform level of 15 to 18 inches so that the bushes resemble large inverted cones. In the third year the bushes are pruned again, also at one uniform level, two or three inches above the previous year's cut. After this, each year's pruning will be at a point from one to two inches above that of the previous year (light pruning), until the yield begins to diminish, when it will be necessary to cut back to twelve to fifteen inches from the ground (heavy pruning). This ought not to be necessary till the bushes are more than ten years old. At a later age, if the bushes are found to give a very low yield, it may be necessary to go even lower than this, and even in extreme cases to cut the bush down level with the ground (collar pruning), but this should not be necessary till after many years, if the garden be properly cultivated, manured and plucked.

The plucking of the tea leaf for manufacture is usually begun after the bushes are about three years old, though a certain amount of light picking is also carried out even before they attain this age. At this period the bushes are well filled and thickly covered with leaf right down to the base, about 2½ to 3 feet in height and with a spread of about 3 feet. They have further a large number of branches springing from almost ground level and forming a good foundation for a large production of leaves. The plucking of the leaves goes on almost throughout

the year, there being several "flushes" as long as warm weather and frequent showers continue. In the first flush of leaf after pruning the extreme tip of the growing branch consisting of the unopened leaf bud together with one or two leaves is plucked; and the two or three leaves lower down which are older are left standing. Following this operation eventually another branch springs from the axil of the leaf lower down and grows out. Two or even three may spring from the same axil and simultaneously a branch may spring from the leaf axil immediately below. All these constitute the second "flush". The extreme tip of this flush is now picked, leaving at least one fully developed leaf to remain on each branch. After the second flush is over, a third flush breaks out from the stem of the second flush and this is plucked in its turn in the same manner. The flushes continue to come on and there may be ten or even fifteen flushes in the year. Not all the branches flush at the same time, and the shoots are therefore not ready to pluck all at one time; this necessitates a large number of pluckings and the bushes are gone over thirty or more times in the year.

Yield of Leaves.—The yield of leaves goes on increasing from year to year from the first year of plucking and reaches its full yield in about the sixth or seventh year when it may be expected to remain steady. This full yield may amount to three or four times the yield during the first year of plucking. The yield of tea, in terms of the manufactured product, varies a great deal from place to place, and may be put down from 400 lb. to 800 lb. per acre, when it has reached the stage of steady yield. Very high yields of even half a ton per acre are reported, but so are low yields of only 250 lb. This dry weight is roughly one-fourth of the weight of the green leaf and generally varies between 20 and 30 per cent. The life of a tea plantation is almost indefinite; the bushes themselves remain in good condition for 25 or 30 years. It is, as a matter of fact, stated on good authority that a bush can live up to 100 years and that in Japan even 200 years old bushes exist. The useful life of a bush seldom exceeds perhaps 20 or 25 years and on every plantation a fair percentage of renewals by means of supplies is necessary and is invariably provided for. Such supply plants are put in when they are good robust plants three years old, and not as the six months, or one year old seedlings usual in a new plantation.

Cultivation and Manuring.—The tea garden has to be given regular cultivation by digging and weeding. Generally this work is undertaken at the end of the rains, when the ground is soft to dig, and the weeds at their maximum growth. Such digging also leaves the soil surface in a loose cloddy or powdery condition favourable for protecting the soil against the dry conditions of the subsequent hot weather. The garden has also to be systematically manured adequately every year. As regards manuring it is to be noted that the special need in a tea estate is

for organic matter. Unlike the coffee estate on which very large quantities of fallen leaves from the shade trees keep up a steady if not increasing supply of organic matter to the soil, the tea estates have almost a bare surface as shade is seldom provided and, even, where it is provided, it is only very thin and sparse. The tea bushes also suffer from a depletion of plant food materials from the continuous plucking of the leaves which imply, in addition, a reduced capacity to assimilaate and elaborate fresh material for growth. The organic matter required may be given in one or more of the following forms, *viz.*, cattle manure, green manure, and composts. As cattle manure can never be obtained in sufficient quantities for direct application, many estates now adopt the practice of utilising such quantities as may be obtainable to mix with composting materials as the 'starter' necessary for breaking down the cellulose matter of the leaves and branches used for composting. This is worthy of general adoption. Many kinds of plant growth including loppings from the shade trees, jungle vegetation around the estates and prunings from the tea bushes (except where it has to be burnt as a measure of disease control) can be used for such composting. The weed Artemesia spp. provides forests of material for this purpose and consists largely of soft easily decomposing tissue and is a favourite material on some estates for composting. Another popular bush which is specially raised is the Tephrosia candida, which is largely grown between the rows of tea, the loppings from which can also be used for composting.

The addition of green material to the soil is secured by growing green manure crops and cover crops and digging them into the soil, and by adding the loppings from shade trees as well. Green manures have been found to be most beneficial to tea, so much so, in fact, that it is believed to be the best form of manuring. The green manure crops grown are both quick growing leguminous crops with a creeping or low habit of growth which furnish a heavy tonnage of green material within a short period of a few months, or somewhat tall growing crops which occupy the ground for a longer period of even some years, but which furnish green loppings frequently. To the former class belong many of the pulses like cow peas, black gram, green gram Mati kalai (Phaseolus aconitifolius,) Crotalaria striata, Crotalaria anagyroides, Tephrosia vogelli, etc.; all these cover the ground quickly and can be dug into the soil in the course of some 70 days or even earlier. To the second class belong the crops Tephrosia candida, Dhaincha (Sesbania aculiata and other species), and Tuver or togare (Cajanus indicus). The Tephrosia is a general favourite and is largely grown between the rows of tea and can be kept on for several years; the Dhaincha finishes its growth in a season, but many species can be kept on for years; the 'togare' finishes its growth in about five months and has to be cut down thereafter.

While the addition of these manures should be a constant and basal factor, tea will have to be manured with concentrated fertilisers also. The incessant plucking of leaves is a serious drain which will have to be adequately made good. A 700 lb. crop is estimated to remove 32 lb. of nitrogen, 6 lb. of phosphoric acid and 15 lb. of potash from an acre and if we remember that only a part of the plant food applied is actually taken up by the crop and also the loss of the fertiliser that should be taking place through surface wash and underground leaching in these regions of heavy rainfall, it will be realised that considerably more than the above quantities of plant food will have to be applied in the shape of manure. Furthermore it should be pointed out that although the striking response is to nitrogenous manuring, in the interests of the permanent health of every part of the plant and of the quality of the leaves, all the three elements of plant food will have to be supplied. Lime is seldom or never needed, and may as a matter of fact prove even harmful, as tea does well only on acid soils with a pH value as low as 5·0. On a good basis of green manuring, a fertiliser consisting of 2 cwts. of groundnut oil cake, 1 cwt. of ammonium sulphate, 2 cwts of superphosphate, and ½ cwt of suphate of potash per acre may be suggested as a suitable manure, which can of course be varied in the light of experiment on particular estates.

Grades and Quality.—A number of grades in quality are recognised and all of these depend upon the type of leaf of which each is largely made up. It has already been stated that the green leaves picked consist of leaves of different ages. Beginning from the topmost or youngest leaf, really the unopened bud, and proceeding downwards, each successive lower leaf is older than the one above it. These different leaves yield teas of different quality. The highest quality is yielded by the youngest leaf and the quality goes down successively as the leaves are older. Plucking is classed broadly as 'fine', 'medium' and 'coarse'; the plucking of the tip with one or two leaves is called 'fine'; that with the tip and three leaves is called 'medium' and that with the tip and four leaves is called 'coarse'. When high quality is the object, 'fine' plucking is resorted to, and when quantity is the object 'medium' and 'coarse' pluckings are adopted. The 'fine' pluckings give the quality named 'Pekoes', which is itself divided into 'Flowery' and 'Orange'. The 'Flowery Pekoes' come from the buds alone and the 'Orange' from the first young leaf. The medium and the coarse pluckings give the 'Souchongs' and 'Congous'. On an average branch of the tea bush after the flush, the green weight (in grains) of the different classes of leaf has been found to be as under: flowery pekoe or tip ½, orange pekoe leaf, 2½, first Souchong 8, second Souchong 8, first Congou leaf 9, second Congou leaf 8 and stem 16.

The pekoes and the Souchongs and Congous are further classified into 'brokens', 'dust' and 'fannings'. It must be

explained that these various grades are separated out only *after* tea is manufactured, in whatever way it may have been plucked, whether as 'fine', 'medium' or 'coarse'. The manufactured tea is passed through a number of sieves of different mesh, both whole and after a certain amount of chopping; the different classes of leaf dry and shrink differently in the process of manufacture and lend themselves to be separated out in this manner.

Manufacture.—The manufacture of the green tea leaves into the tea of commerce is conducted in large tea factories but the processes are, in essence, the same as have been practised from time immemorial; they are however capable of better control at every stage and of being carried out on a very large scale and with the minimum of human labour. The processes are mainly four in number, *viz.*, 1, withering; 2, rolling; 3, fermentation; and 4, drying. Divested of working details, important though they may be, the following is a brief account of these processes:—

The 'withering' merely consists in allowing the freshly picked leaves to dry somewhat until they lose part of their moisture, during which process they become limp and somewhat tough and assume a twist in shape. If the leaves are spread in a thin layer in a well ventilated room overnight or approximately for 18 hours, the 'withering' is generally complete to the degree required. The 'withering' really prepares the leaf for the next process of rolling. If the leaves are not sufficiently withered, then they will be ground up into a sloppy soft mass in the rolling process, the moisture being too great. In the factories very spacious withering lofts are provided with tiers of trays on which gunny (hessian) cloth is stretched for carrying the leaves; good ventilation is provided by means of fans and arrangements exist even for circulating dry air should conditions require it. Usually the leaf loses about ½ of its moisture during the withering. In the withering process, an increase also takes place in the content of the enzyme in the leaf, which helps to produce the special flavour of the tea in the subsequent processes. Recent work, (W. S. Shaw) which makes out that the special quality of tea is due to the substance 'caffeine theotannin,' shows that the combination takes place in the withering stage.

2. The 'rolling' consists in bruising the leaves withered in the above manner, by subjecting them to the grinding or pressing action of two hard surfaces, one moving over the other, such surface being provided by granite slabs. The rolling mills have many mechanical details, such as hoppers to introduce the leaves, doors to let out the rolled leaves, etc., but the most important one is for adjusting the pressure over the leaves during the 'rolling.' The leaves are crushed and bruised, the leaf cells are broken and the cell contents, including the much prized oil, flow over and wet the outer surface of the leaves, there to undergo the fermentation or oxidation (or 'oxygenation,' as it is properly

to be called) of the next stage more thoroughly. Care is taken to see that the temperature does not rise much in the leaf under the rollers, which may lead to fermentation prematurely.

3. The rolled leaf is now subjected to 'fermentation'; this is effected by transferring it, as it comes out of the mill, promptly on to a clean cement floor or tables with zinc tops, where it is spread in a layer about one to four inches thick and then covering the layer over lightly with a cotton cloth. The room is kept cool by sprinkling the floor with water, if necessary. The fermentation sets in and proceeds rapidly and is complete in six hours at the most, the actual completion being judged by the colour and smell of the leaf. The process is one really of the taking up of oxygen, rather than 'fermentation' proper. A yellowish copper colour is taken as a good indication of correct fermentation while a black colour indicates over-fermentation; the matter is however one for expert practical judgment. All the 'cup' qualities of tea, colour, body, pungency, strength and flavour depend a great deal upon the correctness of this stage.

4. The next process is the stopping of any further fermentation, the killing of the ferment and prevention of all further organic changes, and then the slow desiccation or drying out of the leaf. The temperature for this process is so adjusted that it is not so high as to drive out the essential oil and other aromatic ingredients in the tea. The temperature at the start or first stage is rather high, ranging from 230°F. to 280°F.; later on it is reduced to about 200°F. and towards the close of the process even lower. The tea leaf at this stage is crisp, dry and brittle and can be rubbed between the hands into a coarse powder. The moisture content of the leaf is brought down to about 6 per cent.

The subsequent processes consist merely in sifting the tea and sorting it into the different grades already mentioned by appropriate sieves, and packing them in air-tight containers usually wooden chests lined with aluminium (formerly lead) sheet.

Black Tea and Green Tea.—The above process of manufacture yields the ordinary tea, or 'black' tea, which is the kind largely produced. Another kind manufactured, which is less general in use but which has a large vogue in the U. S. A., China and Japan, is what is called 'green' tea. Although the best quality of green tea is said to be got only from the Chinese variety of the tea plant, all varieties of the 'Assam indigenous' type being grown in India, Ceylon and Java can be manufactured into 'green' tea. The method of manufacturing the 'green' tea comprises the rolling of the tea leaves and of the drying, *i.e.*, only two out of the four processes involved in the making of 'black' tea and described above. The 'rolling' brings to the surface of the leaves the essential principles in the leaf cells by bruising them, so that they may the more readily get into the beverage prepared therefrom and the drying which follows immediately prevents all

fermentation and chances of decay, and further brings the tea into the dry marketable condition. It will thus be seen that the fermentation is purposely and strictly avoided; the green colour is thereby retained and the cell contents of the leaf preserved almost unchanged. In one kind of machine, as a matter of fact, the leaf is first 'sterilised' and the enzyme killed so that no more oxidation or fermentation can take place, and is then subjected to the rolling process.

Botany and Varieties.—The tea plant—Camellia theifera—belongs to the natural order Ternstrœmiaceæ, to which the beautiful flowering plant 'Camellia japonica' belongs. It is a low growing evergreen shrubby bush hardly more than 3 feet high or a large tree attaining a height of 30 to 40 feet depending upon the variety. The leaves are simple, alternate, elliptical or obovate-lanceolate in shape, acuminate, the margins serrate, the surface generally glabrous with the under-surface sometimes pubescent. The size of the leaves varies to a remarkable degree in the different types. Thus in the 'Cachar indigenous' they are 12 to 14 in. long and 6 to 7 in. broad; in the type called 'Naga' they are 6 to 9 in. long and 2 to 3½ in. broad; in the 'Manipur' and 'Assam indigenous' they are 6 to 8 in. long and 3 to 4 in. broad; the 'Chinese' has leaves which are very small, *ie.*, 2 to 3 in. long and about ½ in. across; the hybrids vary a great deal in this as in other characters. The 'Chinese' is a dwarf type while the others are tall growing types. The leaves in the former are dark green and leathery while in the latter they are light green and silky. These tall growing types are native to the Brahmaputra valley and two of them under the names 'Assam indigenous' and 'Manipur' are the types now grown throughout India, Ceylon and Java. They are indeed best adapted to the tropical conditions of temperature and rainfall. The low-growing bushy kind or 'Chinese' is largely cultivated in the colder latitudes of China and Japan. Having been introduced into the tea districts of Assam in the early days of tea cultivation in India, the Chinese type has freely crossed with the local or 'Assam indigenous' and many hybrid types have arisen as a consequence, many of which are also largely under cultivation. They are all hardy and intermediate in most characters between the sharply differing Chinese and Assam types. The flowers of the tea plant are white in colour, fragrant, and about 1½ in. across. They are bisexual; the petals are five in number and the stamens which are yellow in colour are many. The ovary is superior and is three celled. The capsule is woody and when ripe splits and sheds the seeds. The tea plant is remarkably long-lived, cultivated bushes are known to live for 30 years and more while some bushes in Japan are reported to be 200 years old, and being still plucked for leaves.

Pests and Diseases.—The tea bush is subject to many insect pests, of which the most serious are (1) the mosquito blight and

(2) the red spider, though the latter is strictly not an 'insect'. The mosquito blight is due to attacks by a bug,—*Holopeltis* (*also antoniis*) *theifera*—the adults of which fly about and resemble mosquitoes (hence the popular name). The damage is done both by the young and the adult bugs. The adults bore into the leaves and deposit eggs, from which the young bugs emerge and burrow into the leaf tissue on which they feed; the adult bugs also feed on the leaves by puncturing the leaf surface and sucking the sap. The bushes, especially the tender growing portions, become covered with these innumerable punctures due to which the leaves shrivel up and blacken. No really efficient remedies are known. Spraying with insecticides taints the leaves; moreover as the pest occurs when there are heavy rains, the spray is easily washed off by the rain. In the early stages some relief may be had by catching the adult bugs (mosquitoes) by nets, sticky sheets or winnows or mats. A light yearly pruning of the bushes so as to get an early crop and a good proportion in the first flush, is also advised, in the view that the early crop escapes the blight. The period for such early pruning is from November to February.

The 'red spider'—*Tetranychus bioculatus*—is a very small mite, red in colour, which sucks the juice of the leaves. They feed in immense numbers on the leaves, which now look tinged with red, and soon shrivel up and die. The mites are found both on the young and on the old leaves, though the latter are more favoured. The damage is very serious during the period of the attack which lasts until the beginning of the rains, when it disappears. The yearly attacks of the red spider weaken the bushes permanently making them an easy prey to attacks by parasitic growths. Dusting the bushes with flowers of sulphur, preferably mixed with wood ashes, controls the pest effectively during the years of application. The dusting is applied shortly after pruning and long before the appearance of the mites; the bushes are wetted by water from a garden syringe prior to the dusting so that the dust may adhere well to the pruned bush.

Many other insect pests are also common, most of which cause damage by sucking the sap in the leaves and making them unfit for plucking, besides weakening the bushes themselves. These are thrips of sorts, the green fly and the pink mite. There is also a shot hole borer which attacks the branches. These are however of minor importance when compared with the first two pests. One of them, *viz.*, the green fly, is even considered somewhat beneficial, provided the attack is only mild, because it sucks and removes much of the watery portion in the sap of the leaf and to that extent makes the latter richer in the solid constituents and so better in quality!

Fungus and other diseases.—The tea bush is subject to a large number of fungus and other diseases which attack all parts

of the plant, the roots, stem and the leaves. The root diseases go under the general name of '*stump rot*', though such rot is caused by several organisms. The symptoms of all are however very similar; the leaves begin to wither and the bushes die rather suddenly. "On digging it up, it is found that the roots are encrusted with a mass of sand, earth and small stones, intermingled with bark and the mycelium of the parasite, the whole forming a gritty coating which is very characteristic"—(Butler.) In the early stages the colour is brown but later it turns black. The commonest stump rot diseases are due to the fungus '*Ustulina zonata*' and the fungus '*Rosellinia Spp.*, In both cases the infection comes from the dead and decaying stumps of old shade or jungle trees which have been cut down, and the stumps allowed to remain in the ground; from this as centre the disease spreads outwards, the bushes are attacked one after the other, the leaves wither and turn brown and drop off, and the whole bush dies. Infection spreads only through the soil and the disease is not air borne. The method of control is almost the same for all the stump rots and consists in preventing the spreading of the infection through the soil or along the roots. The dead stump and a few bushes around it are to be isolated by means of a trench 18″ deep, the soil being thrown inside the circle. Diseased bushes together with their roots are to be carefully gathered and burnt. It is said that the application of chemicals like sulphate of iron, sulphate of aluminium and bazaar alum to the soil in the trenches acts as a check on the spread of the disease. The liming of the soil, sometimes recommended is on the other hand strongly to be discouraged, as the tea plant does not tolerate alkalinity of the soil round the root.

The worst disease attacking the stems and branches and also the leaves is the "red rust"—*Cephaleuros mycoidea, Karst*—which is an algal parasitic growth, unlike many of the fungal diseases. When confined to the leaves, the disease is not of any moment but when it spreads and covers the branches the damage to the bush becomes serious. These become greatly weakened, growth ceases prematurely, and the leaves on them become chlorotic. The growth of the parasite on the branches is red in colour and on the leaves it appears as orange yellow circular patches. The disease is cumulative in effect and the death of the bush takes place only after continued neglect. The disease is spread through wind and water. Among remedial measures, the spraying of the bushes immediately after pruning, with Bordeaux mixture is fairly effective; a more satisfactory measure of control is to increase the vitality of the bush by manuring and cultivation and thereby enable it to resist the disease better.

Among the leaf diseases causing much damage are the 'grey blight' and the 'thread blight.' The 'grey blight'—*Pestalozzia guepini*—is a fungal growth on the leaves which not only depletes the leaves of the sap but also produces brown dry patches

which later develop into holes on the leaves. The disease can be kept in check by pruning off the affected twigs and burning the prunings.

The 'thread blight'—*Stilbum nanum*—also appears on the twigs and leaves as a threadlike fungal growth spreading fanwise on the underside of the affected twigs which eventually dry up and die. In bad cases the whole bush may die. The blight also attacks and persists on many forest trees, so that these form a permanent source of infection. The fungus spreads from plant to plant in a circle from any which may have become accidentally infected. There are no satisfactory methods of control. Singeing the affected bushes, spraying with Bordeaux mixture, lime sulphur and other fungicides are said to have been tried with varying success.

Chemical Composition and Uses.—The active principle to which the action of tea as a beverage is due is the alkaloid caffeine (also called theine). It stimulates the action of the heart and in that respect has medicinal value. Ordinary dry tea will contain from 2 to 5 per cent of this alkaloid. In fact tea fluff—the fine dust which rises when tea is being sifted in the factory and which is a waste product—is collected and sold for the extraction of caffeine, for which it forms the most important commercial source, though at present much is being made synthetically. This fluff usually amounts to about 2 per cent of the tea made in the factory. Much of the quality of the tea is due to the flavour and aroma peculiar to tea; these are imparted to the tea by the peculiar volatile oil. The green leaf contains about 0·05 per cent of this oil and this is sought to be both increased and prevented from dissipation, in the course of the manufacture. It may increase slightly at the withering stage and may largely decrease at the drying stage, when too high a temperature will drive off a great portion. The most notable constituent of the tea leaf is tannin, or theotannin, of which the green leaf will contain from 13 to 18 per cent according to the age of the leaf. In the manufacture of tea the percentage of the tannin is considerably and gradually reduced at each stage. The tea contains an enzyme, which acts upon the tannin and in the presence of air and the bruised condition of the rolled leaf, in which the cell sap is all brought to the surface, the tannin is oxidised and reduced in quantity. The manufactured tea will contain only about 4 to 5 per cent of tannin against the 13 to 18 per cent in raw leaf. The 'green tea' as already explained, avoids the process of oxidation as much as possible and the tannin is therefore not lost to the same extent. When made into 'green tea' the tannin content may amount to 10·5 per cent, which is a little less than in raw leaf and at least twice as much as in 'black tea'. The astringent quality of tea is due to the tannin and the less of it in the infusion the better is the tea as a beverage. Too long a soaking of the tea leaf in hot

water dissolves out more of the tannin, making the tea bitter and unwholesome. The actual constituents of the tea which give it its "cup" quality are not known definitely but recent work (W.S. Shaw) attributes it to the production of a compound of caffeine and theotannin, in different relative proportions. For instance, 'in high elevation tea' the proportion of caffeine to theotannin is found to be 1 : 4·5, and in 'medium elevation tea' to be 1 : 4·5, and in low elevation tea to be 1 : 4·8. Similar ratios obtain in the leaves of different ages; thus in the bud it is 1 : 3·4, in the first leaf 1 : 3·9, and in the second leaf 1 : 4·5. According to these investigations there is no reduction in the content of theotannin as between the green leaf and the manufactured black tea, as described above and as generally believed, but there is only a change in the ratio of combination with the caffeine. The cup qualities including the aroma of tea are demonstrated to be reproduced in infusions of pure caffeine theotannate, a fact which lends strong support to this view.

Production and Trade.—The total area under tea cultivation in India is about 825,000 acres, distributed over the several provinces roughly as under:—Assam-439,801; Bengal-201,900; Bihar-4,000; Madras-76,718; the Punjab-9,443; the United Provinces-6,608; and Coorg-400 acres. The Indian States account for a total of 84,759 acres, made up as follows:—Travancore-77,684; Mysore-4,389 and Cochin-2,686 acres. The total production of tea is estimated at an average of 425 million lb. per year.

The large bulk of the production, amounting to over 80 per cent of the crop, is exported. In 1937-38 the quantity exported amounted to 334 million lb. valued at Rs. 24 crores. A comparatively small quantity is also imported, which amounted in the same year to 3½ million lb. valued at Rs. 18 lakhs.

IV. ARECANUT.

VERNACULAR NAMES FOR ARECANUT:—*Kannada*—ADIKE, *Tamil*—PAKKU; *Telugu*—VAKKA; *Malayalam*—PAKKU: *Hindustani*—SUPARI.

The arecanut also called 'betelnut' is the product of the areca or betelnut palm and is perhaps the most widely used article of consumption in India. The chewing of the betelnut along with betel leaves and a little lime is a habit which is prevalent among all classes of people, of all communities and religions, rich and poor, men and women, and young and old. Not only is it an essential adjunct to every meal which is invariably rounded off which the chewing of this betelnut preparation but its use on other occasions is common, and is

comparable in this respect to the smoking of cigars, cigarettes or pipes in other countries. The offering of betel leaves and betelnuts moreover forms an all-important part of all auspicious occasions such as weddings, and similar celebrations, and indeed at all times, as a customary courtesy when visitors or guests are received. It is therefore available for sale in all parts of the year and in every part of the country including the humblest villages.

Distribution.—The arecanut palm flourishes in the maritime climates of the tropics; and Ceylon, Malaya and the Dutch East Indies, the East Indian Archipalago, generally, and peninsular India have long been important centres of production. The cultivation cannot be said to be confined to coastal tracts but extends considerably inland certainly up to about 250 miles from the sea as on the plateau of Mysore. In India though peninsular India generally and the southern districts especially are the largest tracts of cultivation the tree can be found growing up to about Lat. 24 N.

Altitude and Climate.—In respect of altitude also it has a wide range, from sea level up to an elevation of 3,000 feet as in the case of Mysore. The areca palm requires an ample supply of moisture in the soil and requires a plentiful rainfall throughout the year as in the case of Ceylon and the East Indies or abundant irrigation during the rainless months as is the case in India. It flourishes in tracts of very heavy rainfall such as the Malnad taluks of the Mysore State where the annual rainfall may go up to 200 inches, as well as in the dry districts of the eastern half of Mysore, where the slender rainfall of even 20 inches is supplemented by irrigation from tanks and substantial wells. A cool and somewhat moist atmosphere is generally essential, and for this purpose the areca nut palm is grown in the midst of large shady fruit trees like the mango, jack, guavas, oranges, cocoanuts, etc., in the case of mixed plantations or in the case of pure plantations along with a large admixture of plantains, which are kept up continuously by regular annual supplies. Mixed or pure, this intercrop of plantain is almost an invariable feature of areca gardens, where they help to cool down the atmosphere.

The areca palm is very sensitive to drought and hence an assured supply of irrigation water in summer months is very essential. This necessity greatly limits the area where it can be grown. In this respect it is a great contrast with the two other important palms, *viz.*, the cocoanut which will withstand considerable drought and can be grown under ordinary rainfed conditions, and the palmyra palm which grows under waste land conditions.

Soils.—The arecanut palm is grown on a wide variety of soils. In the malnad taluks of Mysore, the foothills and the slopes of the Western Ghats, in Southern Bombay, Malabar and South Canara, the predominant soils are the typical reddish clay soils spoken of as lateritic, often mottled with light coloured clays and with considerable admixure of the small rounded

nodules of hydrated oxides of iron common in such soils. On the 'maidan' or the plain country the soils are mostly the dark coloured fertile clayey loams; these and the rich black clay with a large admixture of tank silt common in the tank irrigated tracts are generally favoured. Along the margins of rivers and in the shallow valleys, the soils are of an alluvial character generally a light loam often with the charcteristic alternation of light loams and even sand with fine clays. Black cotton soils underlaid by banded schists can also be seen, but those which have a high salt content or are even mildly alkaline or have much admixture of 'kankar' nodules as in the case of typical black cotton soils are avoided. Soils are mostly of great depth and free from rough rock debris; but shallow soils only three or four feet deep and with a large admixture of coarse, rock particles can nevertheless be met with especially in parts of the Chitaldrug and Tumkur Districts, which depend upon well irrigation. It is however on the deep black fertile clay loams and clays such as are found in the tank irrigated areas that the trees grow with great luxuriance. Though the lateritic loams of the Malnads are important areas of areca cultivation, the good growth is made possible by the peculiar and laborious methods of cultivation and manuring which are designed to build up and conserve the soil and maintain its fertility. Light and sandy soils are seldom suitable for the areca and in this respect also the areca is in marked contrast with the cocoanut palm, the palmyra palm or the date palm.

Cultivation Methods.—1. *Malnads.*—The method of cultivation followed in the Malnad tracts of Mysore and the closely similar tracts of Canara and Konkan is markedly different from the method adopted in the 'maidan' tracts and presents many special and interesting features. The heavy and the torrential rainfall of the South-West monsoon and the broken hilly nature of the country with steep and narrow valleys alternating with jungle-clad upland hills and slopes are the special characteristics of this tract of country and the cultivation methods are admirably well adapted to meet these conditions.

The situation selected for areca gardens is invariably the narrow widths of the valley commencing almost from the head of the valley and going on until where the valley widens out. At the head of such narrow valleys there is invariably a small irrigation tank which contains the spring head and which furnishes the irrigation water during the summer months. The sections of the valley immediately lower down which are devoted to the cultivation of areca run between the steep sides of the valley, and these afford the necessary protection from the monsoon winds and the force of the beating rains. Further down the valley where it widens out the valley loses this protection and becomes, furthermore, too large to be fed by the small irrigation tank at the head. These stretches are therefore devoted to the cultivation of rice which is raised solely with the help of the

rainfall. The valley bottom occupied by the areca gardens is very narrow, seldom more than a hundred yards wide and about double this width will be considered broad. Where gardens have to be extended it is always by increasing it in the width by cutting away portions from the sides. The valley bottoms are generally made in one level but depending upon the slope of the sides, long narrow terraces are also made at more than one level above the valley bottom proper.

After a suitable length of the valley bottom is selected, levelled and prepared, the next operation consists in the digging of the drainage and irrigation channels and the laying out of elevated ridges. Along the middle or natural drainage line the main drain is dug, which is from 3 to 4 feet deep and about 2 feet wide and is led from the head of the garden, to the outlet at the end of the gardens. Irrigation channels are laid out higher up the valley side along the margins of the garden on both sides. The land between the irrigation channels and the drainage ditch is then divided across into equal strips of about 14 feet to 16 feet in width by narrow sub-drains about a foot wide which open into the main drain. The ground or bed between these sub-drains is so built up that a mound of about 2 to 3 feet high is formed along the middle of the bed with the sides gently sloping towards the sub-drains on either side. The earth required for this purpose is what is obtained by the digging of the main and sub-drains, and by the cutting away of the valley side.

The next operation is the planting of plantains as a nurse and shade crop to the areca, supplies of which are to be kept up throughout the life of the garden by repeated replacements, as a part of the routine of cultivation every year. The plantain suckers are put in at the rate of one for every areca seedling and about midway between the pits intended for areca. The plantains are planted in the months of May and June to be followed by the planting of areca in the months of September. Pits for areca seedlings are made at distances of about 7 to 8 feet from each other in the row. The rows themselves are from 14 to 16 feet apart. The pits are made about two feet deep and 1½ feet square and filled with a mixture of cattle manure and fresh earth. Areca seedlings fit for planting are usually 2½ to 3½ years old.

Number of Trees per Acre.—This method of planting gives approximately 400 trees per acre and this is the number which was made the standard in fixing the revenue assessment of this part of the country in the days of the old rulers and is still known as the 'daya' or 'sist' of Sivappa Naik. As a matter of fact, however, the actual number of trees per acre in old gardens is very much larger, being almost three times the number, *viz.*, 1,200. Some ten to twenty years after the first planting, a young tree is put in between two older trees in the same row and after a period of the same interval of time a third one is planted in the same row, so that there are three age groups, the oldest

being almost past usefulness, the next in full bearing, and the youngest coming up and due to take place of the first group, many among which are gradually removed owing to their being too tall and old or owing to having been broken off by the wind. Gardens are therefore very much crowded and the trees are practically less than four feet apart. Malnad areca gardens are moreover generally underplanted with two important subsidiary crops, *viz.*, cardamoms and pepper, in addition to the plantains already referred to. The pepper is put in after the areca garden is about twenty years old and the trees tall enough to serve as standards for the pepper vine planted at its base and trained on the stem. The cardamoms which can be put in much earlier are planted along the margins of the drains. These begin to bear after about three years and the pepper about a year later.

The annual cultivation is elaborate in these gardens. This comprises digging round the base of the trees, application of manure, covering it up with leafy twigs and then the addition of fresh earth. One great object is to prevent as far as possible the washing off of the soil by the torrential rains and the consequent exposure of the tree roots and to replace annually by fresh earth such loss of soil as cannot be prevented. The jungle above the valley on its slopes provides the leaves and twigs required for this purpose. They are cut and stored or brought in as required. After the ground at the base of the trees is dug and weeded, the cattle manure is spread and then the twigs are piled up about three feet high covering the whole of the space between the drains and the ridge between the rows; the new earth is then put on top of this layer of twigs. This fourfold operation is too costly and laborious to be attended to every year for the whole garden and is therefore confined to one-third of the garden. On a second one-third section some items are omitted, and in the remaining third all of them are omitted, except a little digging to remove the weeds. Thus, in any one year one-third gets the full fourfold cultivation, one-third gets only leaves and manure and earth or only earth and manure and another third gets nothing. There is a good deal of variation in the different gardens in the particular items omitted or included but the common factor is the carrying out of the cultivation in this three-year rotation. In the course of some ten or twelve years the elevated ridge between the rows disappears and the ground becomes almost level. At this stage comes the most expensive operation of interchanging the positions of the ridges and the sub-drains. The drains are now filled up with earth and the level raised to about three feet and simultaneously the old ridge is dug and converted into a drain, so that what was formerly the drain becomes the ridge and *vice versa*. The main drain is also fully repaired at this time as well as the irrigation channels. Though custom prescribes this transposition once in about ten years, in view of the cost involved it is carried out only at much

longer intervals extending even to twenty-five years. Very large quantities of earth are required for this work and it is obtained by cutting away the valley sides, which at the same time become level enough for extending the garden a little, if desired. In the planting method described above it will be seen that two rows of areca trees alternate with one drain. This method gives place in many localities to one drain alternating with three or four rows or even six rows of areca trees. This is generally where the rainfall is not so heavy or the soil does not tend to be very retentive. The ridges become less pronounced and carry irrigation channels between row and row. As a matter of fact when we come to the 'maidan' tracts with a rainfall of less than twenty inches, where the need for irrigation is supreme, the drains are omitted altogether and, if provided, are at wide intervals and serve to hold up water in the summer time and provide sub-soil moisture.

Cultivation in Maidan Country.—The areca gardens in the maidan districts occupy open and flat country. The gardens are formed on land commanded by irrigation tanks and occupy the fields nearest to the tank bund and therefore most favourably situated in regard to irrigation water even in the hot weather. In these gardens irrigation wells are also dug as supplementary sources, as an additional precaution against drought. Elsewhere the gardens are raised solely under well-irrigation and in such situations the irrigation wells are very large and substantial ones.

In many places, these 'maidan' arecanut gardens are mixed plantations with mango, jack, cocoanuts, plantains, etc., and the cultivation of areca in these gardens presents no special features.

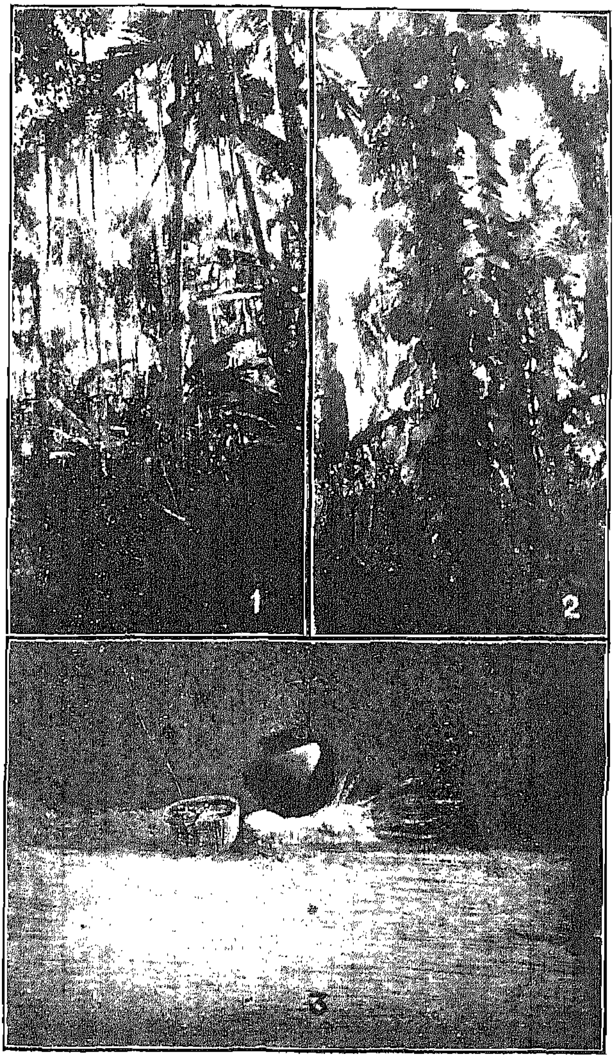
In the areca garden proper, (*i.e.*, pure areca plantations) the cultivation is generally on the flat system and the main provision is for irrigation and the elaborate arrangements for drainage are not necessary as in the 'malnad' gardens. In heavy soils liable to be water logged, drains are however made but at very wide intervals. The trees are planted at various distances such as ten feet by ten feet or eleven by eleven or twelve by twelve feet. After about twenty years a tree is inter-planted so that the distances are halved and later on one tree is also planted in the centre where the diagonals of the square intersect. Plantains are also put in as a nurse crop, but do not form a prominent or a permanent feature as in the 'malnad.' In certain tracts as in Tarikere, Hunsur, Arkalgud and Mysore, large portions of the gardens are devoted to betel leaf cultivation and the areca trees serve as standards for the betel vines. Such gardens are generally leased out to betel leaf cultivating tenants who look after the areca in return for the privilege of growing betel leaf.

The cultivation in these gardens is neither so elaborate nor so systematic as in the malnad gardens; once a year or twice in some localities (*e.g.*, Channagiri) this is carried out soon after

the North-East Monsoon ceases, that is about December and January. This is followed by the application of fresh earth and cattle manure to the base of the trees. The main care in these gardens is irrigation and maintaining sub-soil moisture. Gardens with betel leaf cultivation combined have the manure applied to the betel leaf clumps which benefits the areca trees also. In one curious instance the manure was being applied to the plantain instead of to the areca trees, in the belief that the direct application to the areca favoured the attack of the areca trees by 'Anabe' disease. A second curious form of manuring is to dig oblique pits between one drain and another, fill them with leaves and twigs and cover them up, the garden being thus manured on a three-year rotation in strips of one-third each year.

Leaf Manure in the Malnads.—In connection with manuring of malnad areca gardens with leaves and twigs which is peculiar to that tract, it must be mentioned that special facilities are provided for obtaining an adequate supply of leaves, by reserving the high slopes adjoining the garden on both sides specially for trees as '*soppina bettas*,' *i.e., hills providing leaves.* These trees besides furnishing leaves for manuring, also supply the firewood, fencing material, etc., required by the garden owners. The section of a slope of such 'soppina betta' forms part of the holding which comprises the areca garden adjoining it, and the owner generally enjoys the sole right of cutting leaves, etc., in this section. In recent years in some villages these have been thrown open for common enjoyment by the garden owners of a whole valley, a change which is not liked by these owners. Considerable restriction has also been imposed in the extent to which trees can be lopped, which has led to complaints from garden owners that adequate supplies are no longer available and that gardens are becoming less productive. In order to mitigate this difficulty attempts have been made to introduce the practice of growing a green manure crop like sunnhemp, 'Crotalaria striata' and others under the areca trees, for being cut down and buried as manure. Though deserving of being taken up, the practice has not found favour with garden owners.

The twigs and leaves are used in the areca gardens for two purposes, *viz.*, (1) to protect the soil at the base of the trees from being washed off and the tree roots from being exposed by the torrential rains, (2) to add fertility to the soil. The loppings comprise considerable woody growth and, together with the leaves, form an efficient thatch, which decays only slowly and therefore serves the purpose well and lasts for one or two seasons. Leafy and tender stems such as may be furnished from green manure crops may decompose too soon to afford any such protection. As a source of manure the leaves besides being applied directly to the areca trees as part of the loppings, are used first as bedding under the feet of cattle for some time



(1) Harvesting of the arecanuts, (2) Pepper vines trained on arecanut standards, (3) Boiling arecanuts in copper vessel.
[Mys. Agri. Dept.

Spraying against 'Kole' roga. [Mys. Agri. Dept.

and taken to the gardens or are stored in manure pits in alternate layers with cattle manure, and later on mixed and spread under the trees. This system of making manure is peculiar to the malnad and is somewhat similar to the so-called 'box system' of making manure. The floor of the cattle stalls in this system is much below the level of the ground outside, and of the door way, sometimes up to even three feet; every evening several head-loads of green leaves are brought in and spread on the floor as bedding for the cattle; manure and leaves are left to accumulate under the feet of the cattle for months; generally throughout the rainy seasons. After the rains cease, about the months of November and D. cember, the manure which is now a firmly trampled mass and has reached the level of the doorway is dug out and carried to the gardens. The manure is of course very good in quality, but the discomfort to the cattle which have to lie down on wet green leaves every night and are tormented by a plague of flies is serious and is responsible in a great measure for their general poor condition and high mortality. It is not however all garden owners who allow their manure to accumulate for such long periods; some remove the manure leaf bedding once every few days, others once a week or two, and so on, according to their convenience; such manure is added to great quantities of leaves which are brought daily or brought when convenient and stored. The leaf supply continues as a matter of fact from the month of June to October. In addition to these leaves and twigs, grass is cut from December to February and brought and stored, to be used later on as bedding under the feet of the cattle.

Not all trees are considered equally good for use as manure; some are esteemed as very suitable and others less so or not at all, though opinions are not always alike in this respect. The physical characteristics and the chemical composition of these leaves are worth studying for verifying these preferences. The following are the names of some of the trees which are lopped for this purpose: Xylia dolabriformis Phyllanthus emblica Cariya arborea, Terminalia chebula, Dillenia pentagyna, Terminalia tomentosa, Terminalia paniculata and Eugenia jambolana.

Manurial experiments have been conducted for several years in the Marthur Farm in Mysore, with a view to finding out the extent to which artificial manures can be profitably used for arecanut trees and in order to avoid depending so largely upon the leaf manure and cattle manure which are becoming more and more difficult to obtain in sufficient quantities. As a result of these experiments the following recommendation is made :—

Farm yard manure at 10 cart-loads an acre (or 400 plants), is to be applied and then covered with earth and leaf at 5 cart loads an acre. Every third year 780 lbs. of a mixture made up of 200 lbs. of groundnut oil cake, 80 lbs. of ammonium

sulphate, 200 lbs. of concentrated superphosphate, and 300 lbs. of potassium sulphate is applied to these in addition.

Nurseries.—Seed nuts are taken from trees between 25 and 30 years of age and of the kind yielding the type of nuts desired. The bunches reserved for seed purposes on the trees are those that appear about the middle of the flowering season; in trees with four bunches, for example, only the second and third are reserved for seed and the first and fourth are harvested in the usual course. Nuts are allowed to remain on the trees until they are quite ripe and change fully in colour and begin to drop. The bunches are cut at this stage or the dead ripe nuts are collected as they drop. In both cases these seed nuts are put out to dry for a few days and then taken up for germination. For this purpose the seed nuts are either sown in the ground in specially prepared nursery beds or are made to sprout inside bundles of straw or plantain leaves. These bundles are made up of the seed nuts mixed with some earth and manure and are tied up into circular bundles with straw, dried plantain leaves or leaves of the areca; they are soaked in water and then taken out and kept by the side of the drain or well, where they are watered every day. The nuts begin to sprout in about 2½ to 3 months. They are then taken out of the bundles and planted in nursery beds about 9" apart. If the seeds are germinated in the ground then they are left until they fully sprout and some three or four leaves show above ground. Sown in the months of March to May, the plants attain this stage about October, when they are transferred to larger nursery beds and put in about 18" apart. The seedlings are allowed to remain in these beds for about three years when they are taken out and then planted in their permanent places in the garden. In certain places it is usual to plant out grown up seedlings of two years' growth near the margin of the drains in the garden and allow them to grow there for a year or two more and then transplant them to their permanent places, probably in the belief that this double transplanting tends to make the plants more sturdy. The season for this permanent planting is usually the months of August and September.

The Flowering of the Areca.—The areca trees take from ten to twelve years to come into bearing. The inflorescence which is a spathe springs from the axil of the leaf, the broad base of which encloses it like a sheath until the time comes for the leaf to drop off. The leaf of the areca consists of this sheath-like petiole which encloses the growing part of the stem for about 2 to 2½ feet, ending in a frond which bends away from the stem and gives the graceful appearance to the palm. Spathes do not appear from every leaf axil, but only from a certain number. The number of leaves dropping in a year may be from 4 to 7, but the inflorescences seldom exceed five, though in exceptional cases reach six. In a period of one to six days from the drop-

ping of the leaf the spathe begins to open. The flowers of the areca are unisexual, and both male and female flowers are present in the same bunch. The male flowers open many days in advance of the female flower and drop away almost completely before the female flowers open. Cross fertilisation appears therefore to be the rule in the areca flowers. After fertilisation the ovary begins to swell and the nuts to ripen. In from ten to eleven months from the date of the opening of the spathe, the nuts are quite ripe, yellow and drop down. Some of the flower bunches possess no female flowers at all and yield no areca. This is the case mostly with the young trees in the first few years of their bearing. Some of the older trees do not in some years bear any inflorescences at all. Owing to all these causes, the number of bunches bearing nuts is much less than the total number of inflorescences that appear. Thus in a count kept on the Marthur Farm in 1931-32, out of a total number of 1,610 trees, of bearing age, 23 trees or 1·4% did not bear any inflorescence at all and 121 trees or 7½% shed their inflorescences and carried no bunches to harvest. Further among the 148 young trees which began to flower for the first time 62 trees or 42% had shed their flowers and had no bunches at harvest time.

The areca leaves begin to drop and the spathes to appear from about the month of December onwards and thereafter at varying intervals up to the month of June. These intervals vary from about three weeks to thirty days. The following may be taken as fair samples of such intervals:—

Leaf No.	I	II	III	IV	V
Tree No. 1 ...	4-12-29	3-1-30	26-1-30	2-3-30	15-6-30
Tree No. 2 ...	2-12-29	27-12-30	6-2-30	8-3-30	18-6-30
Tree No. 3 ...	30-11-29	3-1-30	4-2-30	1-3-30	26.4-30

The bulk of the flowering takes place between December and April and finishes by June, but a stray leaf-drop and flowering take place in August giving rise to a very late inflorescence or bunch and again in November, giving rise to a very early inflorescence or bunch.

Harvesting of the Nuts.—For the type of arecanuts prepared in Mysore, the nuts have to be gathered when they are only about three-quarters ripe. At this stage the nuts can be bitten through with some ease. A further rough test is to press the thumb nail into the husk and judge the extent of hardness of of the fibre, which, if at the right stage, will let the nail through into the kernel. The nuts are also quite green in colour. The quality of the prepared nuts depends upon the correctness with which this stage has been judged and the nuts harvested. If the nuts are harvested before this stage or past this stage, then the cured product is poor and shrunken in shape if young, or

hard and light-coloured, if riper. In practice some mixture of such nuts cannot be avoided, and every attempt is made to see that as large a percentage as possible of the cured nuts will belong to the right class.

As the bunches are of varying age, it is obvious that for obtaining the very best results they should be harvested as each one reaches the correct stage; that is to say, there should be as many harvests as there may be bunches on a tree. This however is too costly in labour and, though ideal and sometimes attempted, is not possible in ordinary practice. Another factor which makes it impossible to work up to this ideal is the fact that the early bunches reach the harvesting stage before the rainy season is completely over. This is generally the case in the Malnad tracts, where the harvest has to commence early in September, when the rains have not quite ceased. As the curing of the nuts consists of boiling them entire or in slices and then drying them thoroughly, and as the drying requires generally seven consecutive days of bright sunshine, it will be seen how greatly the prevalence of rains will interfere with the work. As a matter of fact, drying under artificial heat is resorted to, rather than delaying the harvest, and thereby seriously reducing the quality of the nuts. A third factor is the shortage of labour and its cost, which fix a limit to the number of times that the harvest can be conducted for ensuring quality. Notwithstanding the many difficulties three harvests are usually made and, if possible, a fourth. Harvests commence early in September and go on at intervals until about the end of February.

Harvesting coolies climb the trees, test a few of the nuts for the correct stage and then cut the bunch or bunches which may be ready. The cut bunches are let down astride a long rope, one end of which is carried by the climber. The bunches are sometimes dropped down and caught in a gunny (hessian) sheet, which is thrown up very deftly to meet the falling bunch. In these ways the nuts are protected from breaking and damage. After one tree is finished, the climber, while still on this tree, pulls towards him with a long bamboo hook trees which can be reached in this way, tests the nuts, cuts the bunches and drops them. After harvesting as many trees as may be possible in this way, he pulls one of the trees close to him, cleverly hugs and leaps on to it, and, from that tree as centre, harvests further trees. Where trees are close enough, the climber seldom comes down for hours together. The climber is well provided with a crude but efficient appliance to help him both in climbing and in supporting himself, while both hands are free for work; he also carries, slung from hooks on his belt, a bamboo with a crook at the end, the end of a long rope and a basket containing knives and other odds and ends. A climber will cut about 75 bunches in a day at the first harvest and about 200 bunches in the second harvest. A day's wages will be annas twelve to Re. 1 in cash

besides which he is generally fed and looked after more liberally than other coolies. In the case of younger trees whose bunches are at a much smaller height, the bunches are cut down by means of knives fixed to long bamboos, and caught in a gunny. Bunches are not allowed to drop on the ground, if it can be at all helped, both because the nuts may be injured and also because the ground is strewn thick with the remains of the leaf manure and picking the nuts from under this cover means additional labour.

Curing the Nuts—(a) Husking and slicing.—The succeeding operations from curing to sale are generally conducted by the garden owners themselves, a practice universal in the Malnad. In the 'maidan' it is customary in certain tracts to sell the nuts, as they are harvested, and freed from the stalks, to people who cart away the nuts to their villages and there cure the nuts. In either case the operations at the curing sheds consist of the following :—Separation of the nuts from the stalk, husking the nuts, slicing them, boiling, draining and then drying. In places where over-ripe nuts can be sold dried in the husk, these nuts are sorted out before or during the husking process. The husking is done by women coolies, who use for this purpose a curved knife blade, which has a sharp pointed tip, and which at the base is fixed to a narrow piece of board on which the coolies sit; sometimes the blade is rectangular in shape and presents a straight edge. For husking and cutting ripe nuts which are hard, a special nut-cracker-like tool is used. For husking the nut, the calyx end of the nut is pressed against the sharp end of the blade till it reaches the base of the kernel and then pulled out with a slight twisting motion; the pointed end is now thrust a little way from this cut and a section of the husk levered out. Two more thrusts like this remove the whole of the husk. The coolies do the work with remarkable rapidity and almost mechanically. Simultaneously with the husking, the kernel is also sliced. The Malnad nuts are usually sliced into two by cutting across the kernel, which gives the 'batlu (or dish) adike'. Elsewhere they are cut into four or six sections along the length, the kernel being cut into two halves first, and each half further cut into two or three pieces along the length. This gives 'chooru (or piece) adike'. A special kind of the latter is where these are cut into further pieces also along the length, which gives thin longish shreds, called 'lavanga chooru'. In the Sagar Malnad, nuts are also prepared entire, that is, without slicing at all; these are called 'Idi (whole)'. Over-ripe nuts do not lend themselves to slicing, and they are boiled entire, except where they can be sold dried in the husk, in which case they are left unhusked and are not taken up for curing at all.

The husking and slicing involve a great deal of labour; the work has also to be got through sufficiently quickly to catch up with the boiling. Nuts are also said to suffer in quality if the

curing is not taken up immediately the bunches are cut down. In addition to the paid coolies the women-folk of the owner's house also attend to the work and even girls lend a hand; the work also continues long into the night so as to have a sufficient supply for charging the boiling vessel early in the morning. Husking coolies migrate in gangs to the areca villages at this time and return to their homes only after the close of the harvest season. An ordinary day's work for a woman cooly will be about 35 to 45 lbs. of kernels, which will cost between five and six annas.

(*b*) *Boiling.*—The next stage is the boiling of the sliced or entire kernels. The boiling is done in a large copper pot over an ordinary open fire. The first boiling is done in plain water, but more generally some quantity of 'Chogaru' is added to the first charge. This material is obtained by drying in the sun, the thick extract which remains in the boiling pot after the season's boiling work is all over. This inspissated material is preserved for use as aforesaid in the following season. It is also the practice to use for the first charge, water in which various barks and roots and other materials which impart a deep brown colour to the nuts have been boiled, and add a little gingelly oil to this charge, which is said to give some shine to the cured product. The kernels, either sliced or whole as the custom of the tract may be, are charged into the pot quite full; as the boiling progresses the charge goes down a little in level, and more kernels are added to bring up the level, and the boiling continued. The exact stage at which to stop the boiling is indicated by the loosening of the germ from the kernels, for which they are tested every now and then in the course of the boiling.

(*c*) *Drying.*—The charge is then taken down and the kernels are removed by means of perforated ladles and, after the adhering liquid drains off, are transferred to the drying platform where they are spread out to dry. In the Malnad these platforms are fairly substantial semi-permanent structures, erected on areca tree posts about 12 to 15 feet high, and built of areca slats in the manner of joists and covered over with drying mats. They are strong enough for men to walk about and attend to the drying work, somewhat like the flat roof of a regular house. The carrying of the nuts up and down this elevated platform along ladders is arduous work and can be rendered much easier by the use of an ordinary pulley lift, which however has never been thought of. The drying mats are strong bamboo mats made in convenient sizes, generally 8′—4′, of which six are required to handle a charge yielding two maunds (50 lbs.) of areca. The mats with the semi-dry kernels are removed indoors and under proper shelter for the night, and also whenever rain is anticipated. It takes seven days of good sunshine to dry the boiled areca completely. Two charges are taken in a day, and the boiling pot is of such size that a charge yields about 2 to 3 maunds of cured areca. After every boiling, the

extract in the pot becomes thicker and more water is added as may be necessary.

When areca has to be harvested sufficiently early in the season for ensuring proper quality it happens that the rains have not altogether ceased and that sun-drying becomes impossible. Arrangements are therefore made for drying the areca by artificial heat, and this is done generally over a very crude smoke fire. For this purpose, a low framework is erected over four uprights about 4 feet above the ground level and on this the drying mat carrying the boiled kernels is spread; below the framework, one or two large logs of wood are kept burning with a low fire, as far as possible, without much flame, a continual watch is kept to see that no flame shoots up and a pot of water is kept ready and handy to be poured on the log whenever it bursts into flame and there is danger of the mat catching fire. This goes on night and day under constant watch in the midst of the cloud of smoke, notwithstanding the irritation to the eyes and nose caused by the acrid smoke. Partial charring of the mats and nuts is not uncommon and serious fires also occasionally happen. The areca cured in this way is much darker in colour than sun-dried areca and also smells of smoke; it generally fetches only three-fourths or two-thirds of the price paid for the sun-dried product.

As a great improvement over this crude, risky and troublesome method, a regular modern drier made of cast-iron with furnace, suitable chimney, drying trays, etc., was installed on the Marathur Farm, where it has been found satisfactory with slight modifications. A brick framework imitation of this drier has been recommended to garden owners, and been adopted by the more progressive among them. The drier referred to is the 'Choola' manufactured by the Tyneside Company, United States of America.

The furnace is suited for burning wood fuel. The drier effects considerable saving in time, occasions less discomfort, and the quality of the dried product does not suffer very much. The results of some comparative tests are given below :—

Form of kernels	Name of drier	Wt. of kernels	Drying commenced	No. of trays used	Drying finished	Time taken
Sliced into 'Batlus'.	Choola.	90 lbs.	4-12-1930 12 noon.	4 of 35 sq. ft. in all.	6-12-1930 6 a. m.	42 hours.
Do	Smoke fire.	90 lbs.	4-12-1930 3-45 p.m.	1 of 35 sq. ft.	7-12-1930 8-45 a.m.	65 do
Do	Brick work adaptation of 'Choola'.	90 lbs.	4-12-1930 6 p. m.	4 of 35 sq. ft. in all.	6-12-1930 9 a. m.	39 do

As ordinarily made, the smoke-dried nuts become bone-dry and for equal weights of charge the yield of smoke-dried nuts is considerably less than if the same is sun-dried. Smoke-drying therefore entails loss both in weight and quality, as compared with the sun-dried nuts.

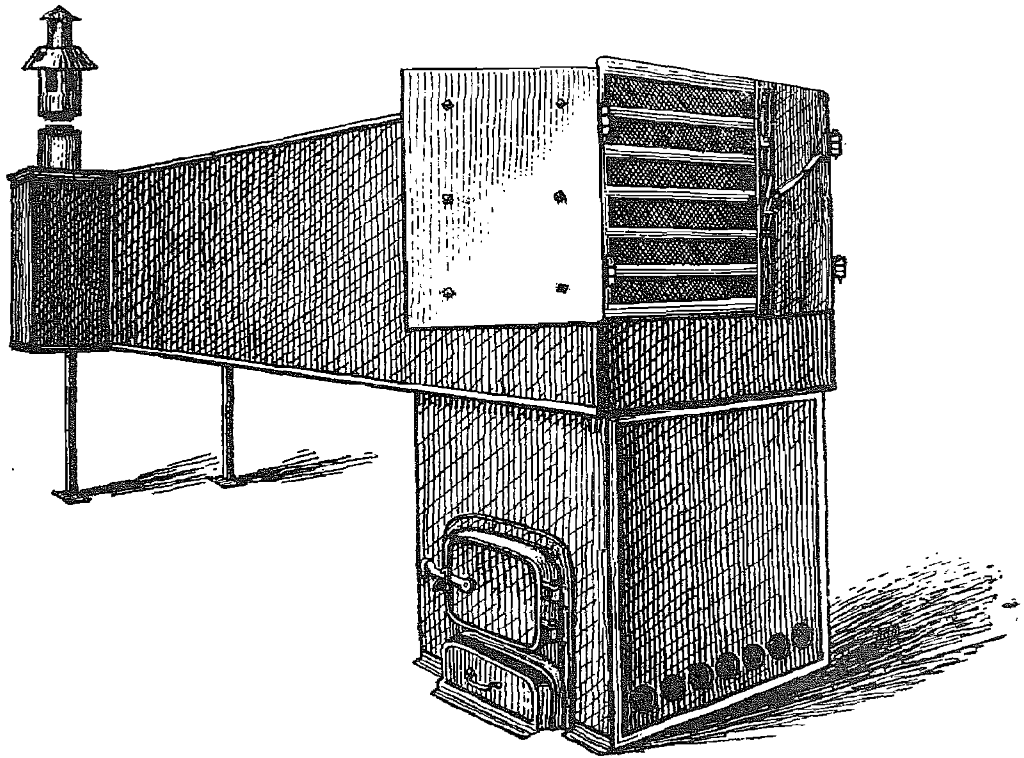
Though the above is the method of boiling adopted almost universally, some variations seen here and there may be referred to. One of these consists in boiling the sliced kernels in four or five charges of plain water successively, and in very special cases to finish up with a boiling in milk. The resulting product tastes exceedingly bland and free from astringency. Another variation is to boil selected nuts in water without husking, and then peel, slice and dry them after the boiling. A third method is to grind up the boiled kernels with various spices, put it up into little discs and then dry. This gives a product which hardly requires any mastication. Still another variation is to husk the nut, beat the kernel and flatten it a little and then boil it.

The 'Chogaru' required for the first time is prepared by pounding up the barks of the Nerale (Eugenia jambolana), Raktha Honne (Pterocarpus santalinus), Manjathi root (Adenanthera pavonina), Pipul stems (Ficus religiosa) and a few leaves of the betel vine, and boiling this in a large pot of water; a little slaked lime is added to the boiling material and sometimes some gingelly oil and a little jaggory. The boiling is continued until the decoction is fairly thick, when it is strained off from the residue and used for boiling the arecanut in; almost every household has its own recipe and a lot of articles most of which yield a reddish colour to the water in which they are boiled, are used in the preparation. The previous year's Chogaru if available is also added.

Change of Composition in Boiling.—The boiling of the kernel, besides other changes, results principally in reducing their tannic acid content. Thus the tannic acid content of samples of kernels, raw and after boiling was as below :—

Sample No.	Tannic acid present in kernels	
	Raw	Boiled
1	30·20	12·04
2	29·75	12·96
3	29·32	15·12
4	23·37	10·75
5	21·88	8·60
6	21·60	12·90

The process is analogous to the change, which takes place during the ripening of the nuts, where the tannic acid content



Arecanut drier—the 'Chula' used on the Marthur Farm for drying arecanuts after they are boiled.
[Mys. Agri Dept.

diminishes as the ripening progresses. Thus kernels in three stages of ripeness contained tannic acid as under:—

1. 'Chickni' (moderately ripe) ... 29·39 percent.
2. Between 'chickni' and 'bette' (ripe)... 21·94 do
3. 'Bette, (over-ripe) .. 13·44 do

The boiling process is therefore evidently designed to give a product of young or just ripe nuts, sufficiently soft and tender for chewing, which will at the same time be deprived of a large portion of its tannic acid or partake in this respect the character of a ripe nut.

The number of harvests per season is generally four and in exceptional cases five or even six. The quantity harvested in each of these harvests greatly varies, the early and late ones being the smallest and the intermediate ones much larger. Even when the harvests are spread out to five and six, a certain number of over-ripe nuts are unavoidable in each case together with varying percentages of nuts in the correct stage and other qualities. The percentage of cured areca at each harvest to the total produce of cured areca on the Marthur Farm is given below :—

PERCENTAGE OF TOTAL FOR THE YEAR.

Harvest No.	1925-26	1926-27	1927-28	1928-29
1	2·0	1·4	44·4	3·9
2	22·0	18·0		71·5
3	65·4	77·9	48·6	21·6
4	10·5	2·9	7·0	2·9

In each of these years the percentage of over-ripe ('gotu') nuts to the total weight of arecanuts harvested was as below :—

Harvest No.	1925-26	1926-27	1927-28	1928-29
1	18·0	42·8	14·8	25·6
2	4·6	11·4		24·6
3	5·2	14·0	5·0	7·0
4	8·0	25·5	4·0	8·0

Grades in Curing Nuts.—The cured areca produce is far from uniform in quality and is a mixture of several grades. There is an elaborate system of grading according to which the bulk produce is sorted, and the price which is offered to any particular lot of the bulk will depend upon the proportion in it

of the different grades. The cured pieces which are the product of kernels in the correct stage of ripeness are known as 'hasa' quality and are the first class. These are distinguished generally by their characteristic colour and their hardness when bitten, broken or pressed with the thumb nail. Those which overstep this ripeness and which can also be distinguished by their characteristic light colour and a harder 'bite' betokening a coarse more woody texture are called 'bette' and belong to the last class; pieces from under-ripe nuts, which are darker and somewhat shrunken in surface, belong to the intermediate class. The broad classification is to separate the produce into three classes, *viz.*, the first comprising nuts harvested a little before the right stage of ripeness, the second those which are about the correct stage, and third the very ripe ones. These are known as 'Chikni', 'Hasa' and 'Bette', respectively, and all can be readily distinguished by their characteristic appearance. In the case of 'Batlu Adike', *i.e.*, nuts cut across in two and cured, the first class may be further separated into the top and bottom halves. The 'bette' class is also separated into two classes one of which is somewhat riper than the other. The last class called 'gottu' is the ripest and is hard and coarse to chew. This is generally sold in the husk, but a fair proportion is also husked and boiled and comes in the last class. A similar division into 'Hasa' and 'Bette' is also made in the case of the 'Idi Adike,' *i.e.*, the nuts which are boiled without slicing. Roughly, the prices will range in the proportion Rs. 9, Rs. 5 to Rs. 3 and Rs. 2 per maund of 25 lbs. for 'hasa', 'bette' and 'gottu,' respectively. Other things being equal such as, uniformity in size, colour, shapeliness and so on, prices depend upon the proportion of the 'hasa' quality to the 'bette' in the lot. In Agumbe, for instance, *three qualities are recognised, viz., the 'rasi' containing not more* than $\frac{1}{3}$ 'bette', the 'hasa' containing more than from $\frac{1}{4}$ to $\frac{1}{6}$ 'bette', and the 'kade hasa' containing less than $\frac{1}{6}$ 'bette'. Prices are generally quoted for the 'rasi' grades which thus allows a third of 'bette'. Within these broad divisions made on the basis of ripeness come considerable further grading according to colour, shape and size. This sorting is made in the warehouses of the large purchasing merchants, who suit the grading to the requirements of particular markets outside the Mysore State. The highest class recognised are those called 'Deshavar' which comes from the Tirthahalli Taluk, and comprise the 'batlu adike' of dark brown uniform colour of the best 'hasa' quality and consisting mostly of the top halves of the sliced nuts, regular in shape and more on the flattish side rather than thick or rounded. The best among these are called 'pheton adike'. Other qualities of the same 'batlu' class are 'Ramachandrapur', and 'Annavara', both of which are Malnad areca and fetch a somewhat lower price than the Deshavar. The nuts of the 'maidan' country, known as 'Toresalu' come in a lower class.

The sliced nuts of the 'batlu' class always fetch a higher price than nuts cured whole; the former involve however considerably more trouble, labour and also give a smaller outturn. Nuts have to be peeled and sliced the same day as they are harvested and the outturn of the cured product will often be about 20 to 25 per cent less than if they are cured whole.

While the system of curing areca by the methods described above is general in Mysore, involving as it does much trouble, labour and cost, the simple system of using the nuts raw prevails over large areas outside in South India and the West Coast. For this purpose, nuts are harvested at a much later stage and when the nuts are quite ripe and somewhat leisurely, because any overripeness does not matter. The nuts are largely husked and consumed raw as they are gathered. Another practice is to sun-dry and store them and husk them only when they are required. A third practice is to ret them in water; the husk becomes loosened by decay to admit of easy removal. These types of nut are of course exceedingly coarse and taste chaffy but have the advantage of remaining long in the mouth, which is appreciated by people who like keeping a quid in their mouths generally with tobacco. Nuts intended for the Bombay market are dried in the husk in this way for about six or seven weeks in the sun and then husked; the husk at this stage is easy to peel.

In South India also, as in Coimbatore and Palghaut, arecanuts are prepared in more than one special form. Among these, the 'chaya pakku' (dyed nuts) and the 'oma pakku' (nuts with 'omum' or 'ajwan' mixed) deserve mention. The former, 'chaya pakku', is prepared in the form of thin circular discs or wafers, which are dyed, so that they assume a deep brown or reddish colour, and a smooth shine almost resembling lacquer. For making this quality, the nuts are gathered in the same semi-ripe stage as in Mysore and the kernels are cut across into very thin circular slices, like thin discs or wafers; these are then boiled in water containing the 'chogaru' already described for the Mysore nuts. The 'chogaru' is however more deeply coloured, the dye cochineal being added, among other things, to intensify the colour. The slices are dried as usual in the sun; they are again smeared over with the 'chogaru' to further deepen the colour and are dried a second time.

The 'oma pakku' is also in the form of these thin wafers. They are made in almost the same way, *i.e.*, cut from the semi-ripe nuts, and boiled. The boiling is however in plain water and much more prolonged than for other qualities. The slices are then removed and dried in the sun. To the water in which they were boiled, is added a quantity of crushed 'omum' or 'ajwan' seeds, and the boiling is continued until the liquid becomes thick; the dried slices are now thoroughly mixed and smeared over with this liquid and dried a second time or kept in the form of a somewhat sticky mass.

Colouring.—Cured areca sometimes lacks the proper colour and has a light or slightly bleached appearance under various circumstances, such as, faulty drying, exposure to rain, delays in boiling, etc. It is then artificially coloured by being rubbed with 'chogaru', the extract from the boiled nuts and then dried. If the colour is very poor then the slices are washed in water and then dipped in a bath of the 'chogaru' with the addition of some gingelly oil. Others also intensify the colour by rubbing the 'chogaru' over the cured areca, even though the latter may have been boiled with the chogaru once already.

Yield.—The yield of areca per acre varies a good deal from place to place as it depends upon the number of bearing trees on an acre and upon the performance of the individual trees and, in the maidan tracts, upon the rainfall. In well-kept areca gardens in the semi-malnad or maidan tracts on deep black soils of the tank silt type and with good irrigation yields up to 60 maunds are not uncommon. From 50 to 60 maunds are generally expected in such gardens every year. In the malnads too similar yields (and even higher in certain places like Humchakatte, Keladi and Hosamane) are reported, which is quite possible, if 'koleroga' does not prevail. The general average known as possible, taking good years with bad and on which long-term leases can be based, is taken as 30 maunds per acre. This yield must be considered low, but as a figure applicable to a wide area and over a long period of years can be taken as average. From 50 to 60 maunds are high yields. Forty maunds is a good yield and 30 is taken as the yield in an average garden. (A maund is equal to 25 lbs.)

Leasing Gardens in the Malnad.—In the Malnad it is very common to lease out areca gardens for varying periods. The minimum period is five years but the more usual and satisfactory custom is to lease out for thirty years. In addition, there are permanent leases running to 100 years, and there are others continuing perpetually, which is tantamount to an alienation, differing only in the condition that the gardens revert to the owners if the male line of succession among the lessees fails. As the gardens are worked as permanent and almost everlasting assets and have continued for several hundred years, lease deeds specify minutely as terms and conditions, the carrying out of the various customary operations in the proper season, such as weeding, digging, maintenance of the main and sub-drains and ridges, their thorough transposition once in ten or twelve years, the customary three-fold operation of digging, application of leaves, manure and earth, the regular yearly planting of areca seedlings and of plantains and of the subsidiary crops of pepper and cardamoms, in addition to repairs to tanks, sluices, spring heads and fences.

The owner's share of the produce is generally one-third of the yield, it being reckoned that cultivation expenses amount to a third, leaving another third to the tenant. Leases specify the

quantities at three to four maunds of areca of the bulk quality per 100 trees of the first or 'daya' planting. This works up to 12 to 16 maunds an acre, (*i.e.*, for 400 trees) a figure which for an average garden yielding 30 maunds of areca is very high. In addition various little perquisites of garden produce are also payable to the owner.

Cost of Cultivation.—The cost of cultivation in an areca garden in the Malnad will generally amount to Rs. 170 to Rs. 190 per acre, made up somewhat as follows:—

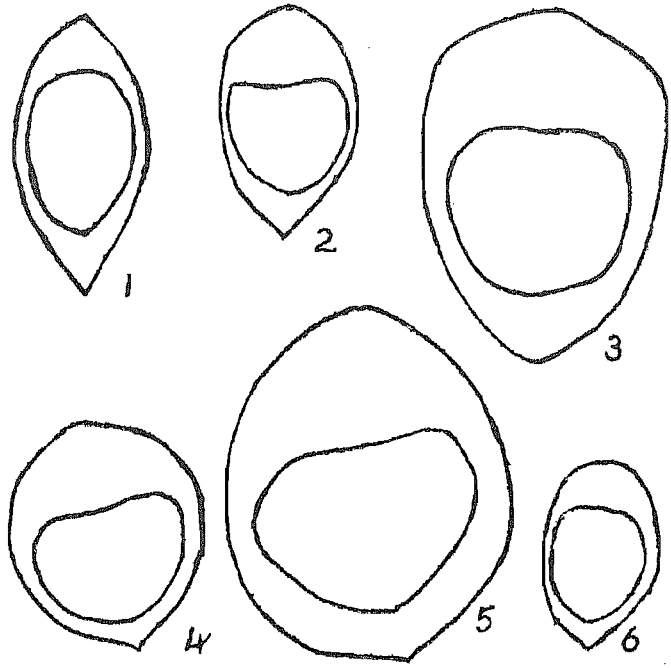
	Rs.	a.	p.
Full cultivation for ⅓ acre ...	25	0	0
Cost of weeding and green leaves ...	7	0	0
Cost of preparing cattle manure with leaves and applying ...	20	0	0
Planting supplies of plantains and areca ...	20	0	0
Fencing repairs	5	0	0
Harvesting and curing charges at Rs. 2 per maund, for 30 maunds ...	60	0	0
Spraying	15	0	0
Cost of erecting drying platforms, small implements, baskets and so on ...	20	0	0
Assessment	15	0	0

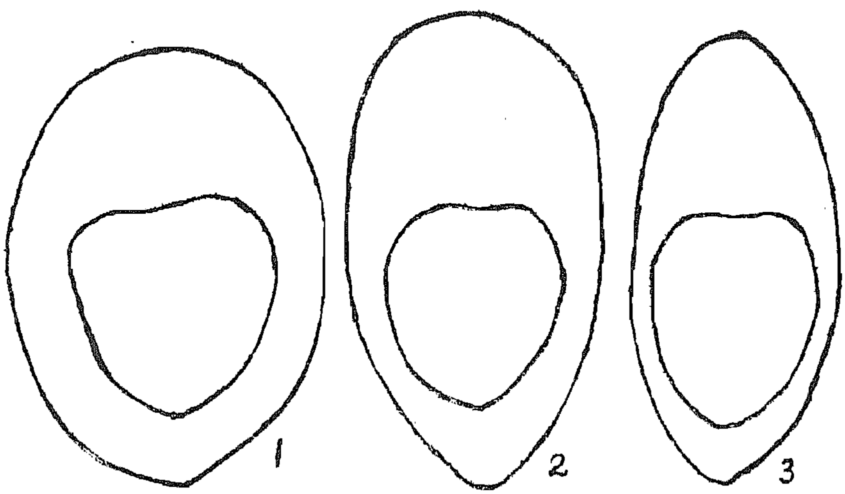
As against these figures many well-to-do garden owners incur additional expenditure mainly in respect of digging and application of leaves, earth and manure, and in repairs to the drains and ridges, which increases the expenditure to between Rs. 250 to Rs. 280 an acre. The yields are no doubt proportionally higher, reaching perhaps 50 maunds an acre. With an average yield of about 30 maunds and with prices ranging at about Rs. 9 a maund an average garden may yield between Rs. 70 and Rs. 100 an acre of net receipts.

Botany and Varieties.—The arecanut—Areca catechu—tree belongs to the natural order Palmaceae. The trees are very tall and slender, reaching a height of some fifty to sixty feet. They consist of a single unbranched whitish stem, smooth, cylindrical and annulate, marked with the scars of the old fallen leaves regularly throughout their height and surmounted by a crown of pinnate leaves. The roots spring from a bole about 18″ to 2′ in length underground, and consist of smooth and thick fibrous strands which are distributed within a depth of some three feet and within a narrow radius round the bole, seldom exceeding three feet. The leaves are 4 to 6 feet in length, are pinnate and the upper pinnae are confluent. The lower portion of the

petiole is expanded into a broad tough sheathlike growth which envelops the growing end of the tree to a length of some two to two and a half feet, and encloses the young unopened spathe. The inflorescence is a spadix encased in the spathes which are solitary and compressed. The spadix comprises a many-branched rachis, on which both male and female flowers are borne. The male flowers are numerous and situated mostly at the farther end of the rachis; they are inconspicuous and small with three sepals and six stamens. The female flowers are much larger, the perianth is accrescent, sepals and petals orbicular, the ovary one-celled, and the stigmas three in number and sessile. The fruit is generally ovoid, about 1½ to 2 inches across and 2 to 2½ inches long, and is coloured brightly orange when ripe. The seed is hard and round with ruminated albumen.

Notable differences in the characteristics of areca are seen only in the size and shape of the arecanut, which correspond to similar differences in the size and shape of the kernels. Differences can be noticed in the bunches which may be either compact, many-branched and well-filled or loose and long with a somewhat open build. Differences are noticed in the taste of the cured kernels, some being very astringent and almost bitter while at the other extreme are nuts which are so bland and free from astringency as to be popularly styled 'sweet arecanut'; between these are others of varying degrees of astringency. Nuts also seem to differ in their degree of hardness, as some are said to melt in the mouth while others require considerable mastication. Again, while in most cases the change in the colour of the skin from green to orange is a sure sign of considerable ripeness, there are a few in which there is no such change in the colour until the nuts are quite ripe and in which the green colour is somewhat deceptive as an indication of ripeness. There are also areca trees which are distinguished as early or late in flowering, although it is believed that such earliness or lateness can be secured by selecting seed nuts from the early appearing bunches or the late appearing bunches, as desired, from the same tree. Nuts are said to differ in the way they cure, some being light and tending to have hollow spaces and others being compact and heavy. There are again trees which are heavy yielding types with a very large number of nuts per bunch and those which are much less so. Obvious and striking differences in trees are to be seen however in the size and shape of the nuts; some kinds are large and almost rounded and yield kernels over 1½ inches across, which are so flattish and disc-like that some sixteen of them can be arranged one on top of the other without the column toppling down. Others are equally broad at the base but are more conical. Among the rounded nuts again there are variations in size. All these types are of practical importance, because by long custom the various markets have distinct preferences to one or other of these kinds, and have to be supplied accordingly.





(*a*) Shapes and sizes (actual) of arecanuts. Entire arecanuts cut along their length and the impressions of the cut face taken, to show the actual size and shape of the unhusked arecanut and the kernel inside.

1, 2, 6. called 'Small' but the kernels are of medium size.

3, 4, 5. are called 'Large' the kernels give large flat '*batlus*' or halves.

(*b*) 1, 2, 3. large nuts from Cochin State. Though the unhusked nuts are large, the kernels are only of medium size.

Tying 'Kottes' or hoods for the areca bunches as a protection against 'Kole' roga. [Mys. Agri. Dept.

Apart from very special kinds, it may be said that those kinds which yield on curing a shapely top-half section moderately thick and slightly dished in the centre are considered best and this quality is yielded by the nuts which tend to be longish rather than rounded. It may be said that gardens which have only any one type, either solely or preponderatingly, are seldom come across; generally more than one type can be seen.

Soils and rainfall conditions are believed to bring about changes in the quality of the nuts which is probably true in respect of the taste of the cured nuts. In respect of the shape of the nuts, the characters are probably varietal.

Two special types may be mentioned which may be classed as distinct varieties, *viz.*, sweet areca, which has been provisionally named Areca catechu var delicosa, and, Ram Ádike. The sweet areca is singularly free from astringency and the nuts are moderate in size, somewhat rounded and the bunches are small The Ram adike tree itself is characteristic; it is distinguished by a much larger stem, and the nuts are much larger and brilliant yellow in colour; the tree fruits moreover throughout the year.

On the Marthur Farm areca trees have been raised from seed nuts classed as big nuts, medium nuts and small nuts, and these have been yielding nuts which retain these size characters. The following table shows the size of the bunches and the size of the nuts of these classes together with some other kinds growing on the farm :—

Name	Number of nuts in bunch	Weight of 100 nuts	Longest length of nut	Widest width of nut
		lbs.	Inches	Inches.
Big nuts ...	294	4·9	1·44	1·35
Medium nuts ...	347	4·3	1·5	1·14
Small nuts ...	501	3·2	1·38	1·1
Long nuts ...	314	4·1	1·55	0·96
Sweet nuts ...	214	3·5	1·41	1·24
Long and small ...	489	3·2	1·43	1·09
Ram adike ...	...	...	2·07	1·28

Diseases of Arecanut.—(*a*) *Koleroga.*—Among the diseases of the areca the most serious is Koleroga. The disease attacks the ripening nuts in the bunches and brings about a shedding of the young nuts to an alarming extent. The disease is a concomitant of the heavy rains of the malnad; the maidan tracts are therefore free from it. The disease has been identified as the fungus disease—*Phytophthora arecae*—which finds a very favourable medium on the wet surface of the nuts durin the

rains, on which the spores germinate and the mycelium develops. The tissues begin to rot and, as the attachment of nut to the stalk weakens, shedding commences. Beginning with the heavy rains of July, the disease progresses continuously or with occasional breaks till the end of the rains in October. A warm damp interval always favours its spread. Young nuts which drop are of course useless and mean a total loss but even ripe nuts which drop on account of the disease are too damaged to be made use of. If no preventive treatment is adopted the disease attacks the crowns of the trees bringing about drying and death of the tree in the course of two or three seasons. The disease is carried from year to year in the remains of the diseased material, such as the dry bare bunches, dead leaves and the refuse in the gardens.

Two kinds of preventive methods are adopted; one of them which is purely a local device consists in protecting the bunches from the action of the monsoon rains by means of a hood or cover. This is adopted by many garden owners and affords a certain measure of protection, if carried out in good time. The hoods are made of the expanded leaf petiole of the areca trees, which serves this purpose very well. Each bunch requires two such petioles which are suitably skewered together to form a protective cover and provided with an arrangement for tying it to the base of the bunch so as to effectively cover it. Every tree top has to be reached and every bunch has to be tied up in its hood. The work is laborious and expensive and the cost is usually reckoned at Rs. 12 for making and tying 1,000 'kottes' as the hoods are called, or about Rs. 25 for an acre on the average. This local method affords only very partial relief. A more efficient method now being adopted almost invariably is to spray the bunches with the well-known fungicide Bordeaux mixture to which is added a small quantity of casein dissolved in lime water as an adhesive and a spreader. The strength of the Bordeaux mixture is 5 lbs. of copper sulphate, 5 lbs. of lime and 24 gallons of water, to which is added one gallon of the adhesive mixture. The casein-lime mixture is made by soaking $\frac{1}{2}$ lb. of casein in $\frac{1}{2}$ gallon of water and mixing it with $\frac{1}{2}$ lb of lime slaked in $\frac{1}{2}$ gallon of water. Although spraying is done only once in the season usually, it has to be repeated when the disease breaks out a second time and nuts begin to shed badly.

The spraying is done by means of pressure sprayers of one or two gallon capacity, fitted with a flexible hose and a nozzle capable of sending a powerful spray mist. The climber carries the spray pump strapped to his back and directs the nozzle to play on the bunches; he then draws adjacent tree tops towards himself and sprays the bunches on them. He then transfers himself to an adjacent tree, as he does when he harvests the bunches, and sprays the bunches on the trees further on. The sprayer is let down every now and then, filled and pumped

and then pulled up again. For spraying 400 bearing trees, the chemicals required will be approximately 6 lbs. each of copper sulphate and lime and ½ lb. of casein. The cost of spraying an acre of 400 bearing trees will amount to between Rs. 2-8-0 and Rs. 3-8-0. The effectiveness of the method will depend upon how thoroughly the bunches have been sprayed, so that the spray solution covers both nuts, stalks and all parts of the bunch and the surrounding portions. To minimise the chance of outbreak in sprayed gardens in subsequent years, old dry remains of bunches should be thoroughly removed and burnt and the ground likewise cleaned of fallen nuts and other refuse. Various bushes and trees, notably Sandal and Colocassias, have been found to be affected by the same fungus and believed to be instrumental in carrying the fungus over from season to season and for this reason their removal from or about the gardens is suggested.

(*b*) *Anabe.*—In the maidan districts areca is subject to a disease, *Ganoderma lucidum*—locally called 'anabe' disease—which affects the interior of the stems and is outwardly distinguished by minute holes on the stem from which some gummy bleeding takes place; a brown rot and a drying up and brittleness of the tissues round about follow, and later on characteristic tough leathery disc-like outgrowths or fructifications called 'anabe' begin to appear. The trees eventually dry up and die and in badly affected gardens the bare patches and stumps of cut down trees become very conspicuous. The loss is very serious, for the reason that well-grown trees in full bearing, that is, the result of some 20 years or more of costly labour, are killed out. Ordinary methods of treatment comprise (1) cutting out portions round the parts where the little holes are noticed and singeing and tarring the surface, (2) drilling an augur hole across the stem near the base or about the region of the bleeding and letting out considerable fluid, in the belief that the disease is due to an excess of sap. Neither of these is effective, though they seem to act as a palliative and delay to some extent the death of the tree. The second method also weakens the tree and makes it more prone to be blown down in the event of high wind.

It is noteworthy that in most gardens where the disease appears considerable lime is present in the soils, generally in the shape of little nodules as in black cotton soils, by which name they should be really described. This has a bearing on the remedy which is now found effective and which therefore is recommended. This method is to dig the soil around the base of the tree, apply flowers of sulphur at the rate of ½ lb. per tree, and then throw the soil back. Destruction by burning of infected material, and of the fruiting bodies of the fungus and the isolation of infected trees in early stages are additional measures to be adopted.

(c) "*Hidimundige*" *Disease.*—A disease of some importance which prevails both in the malnad and in the maidan tracts is known as 'hidimundige.' Trees affected by this disease show a thin and much constricted and tapering crown, with the fronds shorter and the leaflets set closer with a bushy appearance. Both young and tall grown-up trees are affected. It has not been sufficiently investigated but bad drainage and lack of sufficient manure may be some of the causes. A certain amount of mitigation has been obtained in gardens where drainage was improved and a good dose of nitrogenous manure applied.

(d) *Other Diseases and Pests.*—The splitting of the husk at the tip end of nuts, malformations into longish thin nuts of the size of a pencil, brown spots on the leaves, troubles due to ants and so on are come across but none of these is of any importance.

Chemical Composition and Uses.—The arecanut (kernel) is credited with many valuable medicinal properties. It contains a number of different alkaloids together with about 15 per cent of tannic acid and 14 per cent of fat or oil. The most important alkaloid and the one to which its valuable vermicidal properties are due is arecoline, a colourless oily liquid. Other alkaloids are arecaidine, guvacine and arecolodine.

The main use to which arecanut is put in India is as a masticatory, chewed along with betel leaf and lime. It causes the saliva to turn red and gives a red colour to the lips, teeth and the inside of the mouth. The arecanut and the lime are the ingredients concerned in the change of colour. The arecanut is credited with a number of medicinal properties. As a masticatory used in the above manner it has the property of strengthening the gums, sweetening the breath and giving tone to the digestive organs. It has the property of killing intestinal worms, and is generally administered to dogs; even in human beings it is said to cause the expulsion of tape-worms. Catechu of good quality is yielded by nuts which have already been boiled once. The nut when reduced to charcoal and powdered fine is an excellent dentifrice.

In addition to the main product of the arecanut palm, *viz.*, the arecanut of commerce, most parts of the areca palm also find important use in the tract where the palms are grown. The stem of the palm furnishes posts and pillars and joists in house-building; split into slats they can be used as reapers; divided lengthwise into half cylinders and the inside scooped out, they are used as water flumes or when hollowed out without splitting, as water pipes. The petioles or the large expanded sheaths enveloping the base of the crown are used as eating plates; they also form the commonest and very efficient packing material for various articles for which their toughness and pliability make them very suitable; one of their main uses is for the making of hoods or 'kottes' to cover areca bunches as a protection against 'koleroga' as described already. Besides, they

serve many odd purposes such as sun hats, fans and receptacles of sorts, etc. The spathe likewise can be used for skull caps and for wrapping, as it is as good as tough packing paper. The leaves are used for thatch and fuel and the midribs for brooms, skewering, etc., like the midribs of the cocoanut palm. An important by-product is the liquid 'chogaru' or the extract in which the nuts have been boiled. This is rich in tannic acid and is a source of catechu. When prices are good, the material is sent to Bombay in considerable quantities. Another product in the areca garden which at present is practically a waste material is the areca husk. The husks accumulate in very large quantities but at present they are only thrown on the manure heap. The question of finding some industrial use for this material is often raised but so far none has been found which could afford some remunerative outlet for the product. The husks are composed partly of highly lignified and hard fibres and partly of soft tow-like fibres which are too lacking in tensile strength for spinning in the manner of jute. The fibres moreover are not more than 2 to 3 inches in length. Cleaned out of the coarse lignified fibres, the soft portion is recommended for use as tow for packing purposes. Whether it can be suitably mixed with other fibres and spun with advantage is worthy of consideration. Its use as a raw material for coarse paper or even card-boards also deserves investigation. At present, its use is only as manure, but it is so coarse that decomposition is very slow and even after a year the highly lignified fibres do not rot. Its physical condition and its extreme slowness to decay make it suitable as a mulching material where this may be desired. It is used to cover the earthen floors in the open yards inside houses during the rains for preventing the growth of grass or other weeds in these places, which it does very effectively.

Area under Cultivation.—The area under arecanut cultivation in Mysore is about 35,000 acres, in Madras about 108,570 acres, and in Bombay about 17,000 acres.

Trade.—The total arecanut production in India is too small to meet the needs of the country in full. The local production is largely supplemented by imports from abroad, the whole of which come practically from the Straits Settlements. The imports range between 12 and 15 lacs of cwt., per year and in the year 1937-38, the import into India (excluding Burma) amounted to 1,478,265 cwts. valued at Rs. 1,42,84,056. Nearly 90 per cent of the imports come from the Straits Settlements and the remainder mostly from Ceylon, Java and Sumatra. Of the total imports, the different provinces account for the following :—

Bengal	...	...	About 60 per cent.
Bombay	...	...	„ 20 „
Madras	...	...	„ 19 „

There is a small quantity of arecanuts exported from India, which in 1937-38 amounted to 14,473 cwts., nearly the whole of which went to Burma and small quantities to Aden, East Africa and South Africa.

The Mysore trade in arecanuts is mainly one of exports though the imports are also considerable and amount roughly to a third of the exports. The arecanut produced in Mysore is generally of a superior quality and is said to be about 25 to 30 per cent higher in price than the imported qualities. Madras City, the districts of North Arcot, Bellary and Kurnool are important tracts to which Mysore nuts are exported, while the imports come mainly from Palghaut. The quantity exported in the year 1935-36 was 114,300 cwt., and the imports during the same year were 41,500 cwt.

V. THE BETEL VINE.

VERNACULAR NAMES FOR BETEL VINE : *Kannada*-VILIDELE, *Tamil*-VETTILAI, *Telugu*-TAMALAPAKULU, *Malayalam*-VETTILA, *Hindustani*-PAN.

The betel leaf plant is a creeper which is cultivated for the sake of its leaves which are chewed along with areca nut and lime universally throughout India, as a masticatory credited with many properties, such as a digestive, a sweetener of the breath and as a material wherewith to colour the lips red, in the manner of a modern lipstick. Along with the arecanut it is a symbol of auspiciousness and is handed round and is partaken of at all ceremonial gatherings of an auspicious character and indeed whenever friends and visitors call. Like the arecanut too it is sold in every bazaar and a village must be insignificant indeed where the betel leaf cannot be had.

The cultivation of the crop is of the very intensive garden type requiring continuous attention and care; it is also of a specialised character and is generally in the hands of a particular caste or a class of people, who possess a traditional knowledge of all the details of its cultivation. On account of the great amount of manual labour, time and cost involved, betel gardens are small in area, of a quarter of an acre or even a few cents, or where they are larger in area, they are attended to by a number of families each of which forms only a few cents. Betel leaf gardens are established and worked as permanent gardens lasting over even fifty years, but often about thirty years, as semi-permanent gardens lasting for considerably smaller periods of about ten to twelve years, or as comparatively temporary gardens lasting for periods of three or four years, according to the custom of the different tracts. The period will also depend upon the nature of the cultivation, soils, hardness of the vines against aging, disease

and other adverse factors, besides economic considerations. The gardens are either solely devoted to betel leaves often with subordinate crops of different kinds of vegetables raised without detriment to the main crop which is the betel leaf, or form part of arecanut gardens where the arecanut trees serve as the standards for the vines to be trained on, or again in mixed gardens of areca, cocoanuts, plantains and other fruit trees.

Rainfall, Altitude and Soils.—The betel vine belongs to the order Piperaceae and is closely allied to black pepper—, 'piper nigrum' to 'piper longum,' the other pepper-like creeper which is cultivated for its fruits which have great medicinal value and to 'piper cubebs' or 'tailed pepper' which is used medicinally and as a spice. Unlike black pepper which requires a tract of very heavy rainfall, the betel vine can flourish under a wide range of rainfall from over 90 inches down to as low as 10 or 12 inches. It is also cultivated throughout India and from sea-level up to elevations of 3,000 feet.

The soils generally favoured for betel leaves are of the heavy clayey types almost like the black cotton soil with good depth and free from coarse gravel or gritty particles and with much natural fertility. Red loams both light and heavy, of good depth may be said to come next. Light ashy coloured loams are also utilised with suitable manuring and addition of tank silt. Even on the sandy soils of the coast, as may be seen on the island of Rameswaram, for example, which one would regard as quite unsuitable, betel leaf gardens are established chieflly with the aid of very liberal manuring given to the pits in which the plants are grown and of the heavy irrigation through masonry water channels which carry water to the pits without becoming lost in the sand on the way. Likewise too where the physical condition is too coarse even to the extent of being stony, the cultivation is carried on by digging large pits, filling them with suitable soil, and growing the plants in such pits.

Irrigation.—An unfailing supply of abundant irrigation water which will be available throughout the year is indispensable for betel leaf cultivation. It is therefore attempted only where such facilities exist. Gardens are established on land commanded by large tanks, and are further protected by wells as a supplemental source of irrigation. Very often the situations are such that water is obtainable within ten feet of the surface and temporary wells can be easily dug either as independent or supplementary sources of irrigation. In many places large and costly wells form the sole or principal source of supply especially where the gardens are kept on permanently for two or three generations.

Shade.—The betel leaf plant has to be grown in a cool moist atmosphere and with an abundance of irrigation. It has to be protected effectively from the sun by a cool shade. It has also to be protected securely both against the beating force of the

wind and against the dust and dirt that it generally carries. Drainage is essential and provision is made therefor by an elaborate lay out of the ground avoiding stagnation or too much water within the root range.

The shade is provided by trees which are raised in the garden as standards for the vines to climb on, by the areca trees with which they are grown in association and which also generally in such cases form the standards and by the plantain trees which are grown here and there in the garden. The standards are sometimes made to close in over the head and are tied together to form a kind of arbour under which the vines are well protected. In Northern India the gardens are practically covered over with a thatch of grass and stalks of jute, 'daincha', tall grasses, etc., giving them the appearance of thatched huts. The sides of the gardens are everywhere securely protected by means of tall close fencing trees, thick enough to form an effective screen. 'Euphorbia tirucalli' is a favourite fencing plant in Mysore, the lower portion near the ground level being closed in by thorns, as the 'kalli' hedge tends to become somewhat open near the base Elsewhere the tall 'Saccharum arundinaceum,' 'Arundo donax,' 'Sesbania grandiflora' and bamboo poles are used for this purpose, gaps being closed by means of the dry leaves of plantains. In Northern India, the fencing is of the same materials as are used for the thatch.

Drainage.—As regards drainage, where betel leaves are cultivated as part of arecanut cultivation, the drainage ditches are made between every two, three or four rows of the arecanut trees depending upon the stiffness of the soil. In some areas the drainage is still more thorough and the lengthwise ditches are crossed by a number of cross drains also. Another way in which drainage is secured is to grow the betel leaves on high elevated beds which are sometimes as high as four feet. These beds alternate with strips of level ground in which run narrow trenches; water is kept flowing in these trenches with little depressions here and there from which water is taken in pots for watering the beds. In still other methods the betel leaf beds are narrow ridges like earthed up rows, and alternate with narrow channels about a foot deep, which carry water for sub-soil irrigation principally but from which if necessary water is splashed on to the rows. Elsewhere the lay out is more elaborate; there are main drains, which separate a series of betel leaf beds and these beds themselves alternate with cross drains opening out into the main drains. All these different methods are further referred to in the different types of betel gardens described in the succeeding paragraphs.

Standards for the Vines.—As the betel leaf is grown trained on upright standards for support, the provision of these standards is an indispensable requisite. In South India the betel leaf vine is grown invariably on live standards, *i.e.*, on the stems of growing

trees and not upon posts or pillars or other uprights of that kind. In areca gardens which are betel gardens as well, the arecanut trees themselves are the standards and betel leaf cultivation is started in them only after they attain sufficient height for the purpose, which is not earlier than 15 years. In pure betel leaf gardens the standards have to be sown and raised specially for this purpose. There are only a few trees which appear to be considered suitable, if we may judge by the general practice. These are Sesbania grandiflora, Erythrina Indica, Moringa pterygosperma and Eriodedнron anfructuosum. These have the merit of growing quickly, especially the first two. They can be sown almost at the same time as the cuttings of the betel leaf vine are planted, but it is usual to give them a start of one to three months. During the few months they take to grow tall enough to serve as standard, little sticks are put in close to the vines for support as a temporary measure to be removed when the permanent ones become ready. These tree standards are kept free from side branches up to a height of about 12 feet, for the sake of the vines and are also topped about the same height, so that the shade may be low enough. When standards become old, broken or too thick-stemmed, they are replaced by new ones, and the gardens kept on indefinitely. In Upper India, the standards are furnished not by live stems, but by dry branches and stalks of the 'daincha' (Sesbania aculeata) plant.

Manuring.—Manures for the betel vines are only ordinary cattle manure and sheep manure. Tank silt is also occasionally applied, as likewise red earth, sand and such soil ameliorants. In the first 18 months after the vines are planted, manuring is given frequently, about a handful every time the beds are hoed and weeded. Later on manuring is given immediately after the lowering of the vine, on a liberal scale. In certain districts sheep manure at the rate of two baskets per pit or bed of four vines is given twice a year. This quantity will roughly amount to a heap of two and half cubic feet in size. Manures like oil cakes or chemical fertilisers are very exceptional, although in the places where these have been used experimentally, they have proved very beneficial, not only in stimulating growth but in keeping down mildew. It is feared however that the leaves may become coarse and lose the special characters for which they may be esteemed; garden owners are therefore chary of changing over to new manures and there is little or no experimental work affording any guidance.

One of the important operations in the betel leaf gardens consists in taking down the vine from the standard and burying the lower portion in the soil and allowing only the upper portion to grow. The portion thus buried in the soil is generally the vine of two years' growth and the portion left to grow is of the previous season's growth or about one year old. By this process the vine is more or less continuously rejuvenated and the process

is tantamount to raising a new vine. It is universally practised in the Mysore State where the gardens are kept on for years and is certainly the main factor which helps such longevity in the vines. Among other advantages, is the bringing down of the vine to a manageable height for the picking of the leaves, which is sometimes secured by topping the vines. For this process of lowering the vine, it is first carefully untied from the standards, the claw-like roots which cling to the standards are also gently freed and the whole vine brought down. The lower portion intended to be buried is made into a coil, tied up and put in a shallow pit at the base of the vine and covered over with earth. Sometimes a long narrow trench is dug from the base of the lowered vine to the base of the vine diagonally opposite and the portion to be buried is tied up in a longish bundle and laid in the trench and covered. The portion of the vine left over is now tied to the same standard from which it was lowered or to the opposite one. At the third annual lowering, the connection with the vine buried two years previously is severed and the buried portion merely decays like any other vegetable matter. The growing vine thus maintains connection with the growth of the preceding two years always. This lowering is carried out usually in the first half of the year from January to June and the operation is followed by manuring and irrigation. There is also a respite in picking of about two months following the lowering.

The planting material consists of cuttings taken from healthy vines which are obtained by cutting off the length of the vine of the previous year's growth, and dividing this length into 12 or 18 inches sections. Each such cutting should contain from three to five nodes. The cuttings are taken most conveniently about the time that the vine is to be lowered. The planting takes place any month from June to October. The cuttings are planted in such a manner that two nodes are buried in the soil, and one or more nodes are above ground and pointing towards the standards on to which they will eventually be trained. Variations in the methods are noted in the descriptions of the different types of gardens. In some villages it is the practice to raise a nursery of rooted cuttings, and then transplant them in their permanent places. For this purpose, cuttings are planted closely about four inches apart in a well prepared and shaded nursery and some thin branches or twigs are put in here and there in the nursery bed for the purpose of supporting the young vines when they begin to shoot. Good rooted cuttings from three to six months old are taken out and used for planting a new garden or for supplying blanks.

Cultivation Methods.—1. The ground having been prepared by digging, breaking of clods, removal of weeds, roots, etc., and by levelling, and a good fence also raised, the area is laid out into long beds about six feet wide divided by trenches of about

18 inches wide and 18 inches deep. The beds are made to any convenient length up to some forty feet.

In these beds the seeds of the plants intended as standards for the betel vine are sown in two long rows. The standards for the betel are Sesbania grandiflora and Erythrina Indica and Moringa pterygosperma. The trenches are filled with water which is also splashed on to the beds to water the row of standards regularly. In about four months or so when the standards are grown to about two feet, the betel vine cuttings each about 18 inches long are planted along the two rows and at a distance 18 inches from each other. The trenches are constantly kept filled with water, for the beds are watered by splashing the water on to them from the trench. In three months the vines are well established and can be tied on to the standards. Hoeing and weeding the beds and manuring around the beds are both repeated every three months. The standards are then bent forward towards each other, crossed and tied together, or cross poles are tied across them, to make the standards stand firm and not likely to be disturbed or broken by the wind, and the vines as they lengthen are tied to the standards again. Early in the following year from about the middle of January, the vines are lowered by untying and releasing them from the standards, and burying about three feet length of them nearest to the ground, carefully coiled round, in the soil around the vines. Further manuring and weeding follows and regular watering. The vines make fresh growth and send out many branches and the leaves from the latter are ready to pick in another three to four months. The vines are allowed to bear leaves for picking for about 18 months to two years and then the garden is destroyed and the land restored to the cultivation of rice, or other crops. Along with the main crop of betel leaves, considerable miscellaneous crops like vegetables of different sorts and some plantains are grown along the margins of the beds. The betel leaves are picked some three to four times in twelve months.

2. Betel leaf cultivation is in many places carried on in rotation with rice, the betel leaf garden occupying the ground for a period of three years, after which it is given over for rice. The lay out of the garden in such places in South Madras Districts is as described below. Long narrow trenches of about one foot wide and five inches deep and about fifty feet long are dug at distances of seven feet from each other, the earth from the trenches being thrown on to and spread evenly over the ground. On these beds two furrows are drawn parallel to the trenches and dividing the bed into three long strips of equal width of about two feet. Seeds of 'Sesbania grandiflora' intended as standards for the betel vine are sown in these furrows in groups of four to six seeds at distances of four inches from each other. The furrows are then kept regularly watered and the beds are also earthed up from the trenches which are thus

deepened at the same time. Three months after the standards are sown, about the month of October, the cuttings of the betel vine are planted. The cuttings are about one foot long and are planted at the rate of two cuttings below each group of standards. The garden is now fenced very thoroughly and screened effectively both as a protection against the wind and for security. With ordinary cultivation the vines grow long enough to be tied to the standards about the month of February, and about the same time the standards are bent towards each other near the top and tied so as to form a sort of canopy. Three times through the following two years the garden is heavily manured and kept regularly irrigated. In these gardens pickings are made once every month and the vines are also lowered once or topped to reduce the height and induce branching. A number of miscellaneous vegetable crops are grown in and about the gardens, which add materially to the income. After three years or four the gardens are destroyed and given over to rice cultivation. The Sesbania standards are removed and sold for fencing purposes. Leaves to the number of about 160 lakhs are reported to be the annual yield in such gardens.

3. Trenches are dug three feet wide and three feet deep and some 15 to 20 feet long. These trenches are separated from each other by strips of ground left undug which are also three feet wide and the same length as the trenches, so that trenches and level ground alternate with each other. Part of the earth from the trenches is thrown on to the undug strips where it is spread level. The trenches themselves are then filled with good soil, vegetable mould and manure up to one foot from the level of ground. Suitable elevated water channels for irrigation are laid out between every two series of such trenches. In these beds about the month of June—July along the margins and at distances of three feet from each other, are sown three seeds composed of two Erythrina Indica and one Sesbania grandiflora, so that when the trees grow they will have the appearance of a group of three trees planted in each of the four corners of a square of three feet wide. The beds are kept watered regularly and in a week after the seeds of the standards are sown the betel vine cuttings about two feet long are planted at the rate of one for each set of standards. About two nodes length is pressed into the soil near the standards and the free end is carried near the opposite standard; another cutting is likewise planted near the latter and its free end is carried near the first standard, so that the cuttings meet and cross each other about half way between the standards. Sticks of Erythrina Indica and bamboo are put in as temporary supports for the vines until the permanent ones grow up. The beds which alternate with the betel leaf trenches are devoted to the cultivation of vegetables such as radishes, onions, carrots and so on. The cultivation of betel leaf in regard to weeding, manuring, watering and the annual lowering are more or less similar

to those already described. The standards have their side branches removed up to a height of some 15 feet, above which they branch well and carry a shady crown of leaves.

Gardens are also made without any elaborate arrangements for drainage and irrigation trenches, such as are described above; water is derived from low shallow wells and the vines are hand-watered. For this purpose after the area is fenced in and then prepared by digging, the removal of weeds and roots, etc., the dug earth is allowed to weather for about a month during March and April. In the middle of May, the ground is levelled and low basins made for the planting of the vines. These are two feet in diameter and about three inches in depth, and are made at distances of 7½ feet from each other both ways. When the ground is well softened by rain about the months of May and June five cuttings of the vine each two feet long are planted in each basin alongside each other by their middle with the free ends sticking out. The cuttings are shaded and watered daily. Soon after the planting of the cuttings seeds of the trees for the standards are sown in a row along a furrow hoed by the side of the basins, at distances of 18 inches from each other. The standards are the usual Erythrina, Eriodendron anfructuosum, Sesbania, etc. The basins are weeded and manured once a month and watered frequently regularly. Until the standards grow up the vines are trained on to temporary standards of dry sticks put in near the growing vines. The vines are trained on to the permanent standards in a year and the temporary ones are removed. Intensive manuring and cultivation are continued and the vines tied to the standards as they grow. Every year, the lower portion of the vine consisting of the older growth is gently pulled down and buried in the ground. The vines begin to yield leaves from the beginning of the third year and continue to do so, with the usual yearly operations being conducted regularly, almost indefinitely.

4 *Cultivation Method in Areca Gardens.*—The planting of betel vine in the areca gardens with the areca trees as standards is obviously possible only after the areca trees have grown sufficiently tall, which they do only after some fifteen years after they are planted. For planting betel vines in these gardens pits are dug near each tree about two feet square and eight inches deep in the month of May, allowed to weather for a month, filled in and left to settle. A month after some good rains have fallen, the betel vine cuttings are planted in these pits at the rate of five cuttings, two feet in length each in each hole, the free ends being made to slope towards the areca tree standard. The pits are now shaded, and watered frequently. After the vines strike root the shade is removed and the ground weeded and manured. The ground is stirred and weeded every month, when some manure is also given. The vines make enough growth to be tied on to the areca early in the following year. Frequent

waterings are now given and once in two months the beds are hoed and manured. In 18 months after planting, leaves become available for picking. Early in the next year or the third year, the vines are untied and the lower four or five feet comprising the first year's growth is coiled and buried near the vines. Manuring and watering are also given at the same time and the waterings are frequently and regularly continued. The vines give three pickings in the year. Lowering of the vines is an yearly operation, and is carried out from February to May.

Picking the Leaves.—As cultivated in the permanent betel gardens of Mysore the picking of the leaf commences only in the third year after the vines are planted. Leaves are picked only from the branches springing from the main stem and not from the main stem itself. Each vine is picked generally four times a year, but there are places where the vines are picked five times a year or roughly once in two months. On the other hand, there are also gardens where the picking is less frequent being only three times in the year and even only twice in a year. The general practice may be said to be four pickings. All the vines in a garden are not picked at the same time, but the pickings are so arranged that there may be a picking once a week, usually for some particular weekly fair. In a garden where the annual pickings are four in number for instance, the garden is divided for the purpose of picking into twelve divisions which are picked at intervals of about three months. Pickings are of two kinds also; in one, all but the youngest leaf at the growing end of the branch are picked and, in the other only two or three are picked and all the younger leaves are left. The former gives a much larger number of leaves, sometimes even double that of the latter, but it weakens the vine and the annual pickings may be only three instead of four. As the vines are usually too tall to be reached from the ground tall ladders usually resembling a somewhat crude step ladder are used to pick the leaves. The vines are seldom allowed to grow more than ten or twelve feet high, the extra growths if any are pinched off. A year's growth is about six feet in length and the stem above the ground is a two-year growth at its maximum when it is taken down. Leaves are picked by cutting the petiole clean; and for this purpose a sharpened steel thumb nail is used which the picker slips over the end of the right thumb and uses it just as he would use his real thumb nail.

Yields.—The yield from the betel gardens of Mysore which are all permanent gardens grown independently or in conjunction with areca will amount to something like five to twelve lakhs of leaves per acre depending upon the number of standards per acre. The yield in the gardens of South India is ten times as large; in the Vellalur betel area the yield during three years ranged from 4,500 to 5,000 'palagais', each of 2,000 leaves. Yields from other South Indian gardens are given as higher still

amounting to 40 loads, each of four lakhs of leaves. In Bengal (according to Mukerjee) the yield is about 80 lakhs of leaves per acre.

Botany and Varieties.—The betel vine—Piper betle—belongs to the natural order piperaceae. It is a tall climbing vine, with nodes at the stems which swell and bear adventitious roots. The leaves are smooth, cordate, ovate, or obliquely ovate, the sizes varying according to varieties. The plants are dioecious and the flowers are minute in catkin-like spikes. These are however seldom seen on the betel vine.

Varieties in Mysore.—Several varieties are grown in different parts of the country which differ from each other generally in the outward shape of the leaves, in the shade or depth of the green colour and in the taste and aroma of the leaves. The following varieties can be seen growing in Mysore and the names given are descriptive of the shapes of the leaves, These are (1) 'Kumbala balli,'— a vine with very large leaves (literally, vines with leaves like pumpkin leaves) very dark green in colour, tasting somewhat pungent, and generally yielding a smaller number of leaves than other varieties. (2) 'Kari balli' (literally, black vines) the leaves are medium sized, and dark green in colour and generally coarse in texture. (3) 'Nagaballi' which is bland in taste, has small leaves shaped like the hood of a snake and which are light green in colour. (4) 'Ambadi,' which are long and narrowish, light green in colour and have a pronounced aroma somewhat resembling camphor. (5) 'Kanigalu, (literally, oleander-leaved), which are very small and narrow and light green in colour and very bland in taste. There are however a number of different local names describing varieties which are probably the same, more or less as the above ones with such differences as may be induced by differences in soil, and cultivation. Leaves from certain localities are distinguished for special qualities especially in respect of texture and of taste. In the Mysore State, Mysore, Gundlupet, and Arsikere are noted for high class leaves.

The betel vine does not normally bear flowers and fruits, but occasionally an inflorescence here and there may be met with, particularly in some varieties, which look much like 'catkins' or spikes of the pepper plant. Fruits however do not set. As in the case of the pepper plant male and female inflorescences are borne on different plants.

Betel leaves from South India are sent regularly in large quantities to Bombay and Upper India. The annual export from Mysore State amounts to some 35,000 maunds (1 maund= 82 2/3 lbs).

Pests and Diseases.—Betel gardens are looked after very carefully with much attention to what may be called 'plant sanitation' as it is locally understood. Gardens are kept exceptionally tidy and anything considered unclean is excluded—a

caution which is carried to the extent of refusing admission to visitors who may be wearing shoes or sandals. Diseases are rare, probably for this reason, but in recent years there has been considerable loss due to pests and diseases, which however are not many.

1. *Mildew.*—The most troublesome disease of betel leaves is mildew on the leaves. Both young and old leaves are attacked and the mildew patches may be few or spread all over the leaf. In bad cases the leaves drop off altogether, but even if the attack is only mild the presence of only one or two mildew spots on the leaf makes it unfit for any but the poorest markets. Spraying with Bordeaux mixture, dusting with lime and sulphur and spraying with sulphides of potash have all been found to control the mildew, and if the crop of leaves so sprayed can be picked and discarded then the method can be adopted and the disease controlled so that the later flushes at least yield healthy and saleable leaves. The price of the mildewed leaves goes down very low and lots even become unsaleable. The disease has been a source of great loss to growers. Remedies ordinarily applicable to the treatment of mildews are out of the question in the case of the betel leaf mildew, as they all leave a coating or deposit of the material sprayed on the leaves which, however thin it may be makes the leaves unfit for use. Probably one or two pickings will have to be sacrificed, the garden being sprayed or dusted during that interval.

2. *Black Rot.*—Another disease is a kind of blackrot of the laterals and stems, in which the surface becomes black and the vines gradually become weak and dry up in the course of a year or two. The blackening of the stem appears on the stem above the ground and on the portions below. The attacked plants have a drooping appearance in the early stages of the disease and later on dry up completely. The disease was studied at the Vellalur station near Coimbatore and several remedies were tried. Spraying with Bordeaux mixture even though repeated three times within a period of two months did not result in any improvement. Improved drainage resulted in higher yields and so did the liming of the soil. Earth-worms have been suspected, but it was found that increased yields were obtained notwithstanding a larger population of earth-worm. The importance of sufficient drainage was however strikingly brought out. In these experiments vines grown on ridges about a foot higher than beds made side by side according to local practice gave not only higher yields but also a better quality; the increase in yield varied from 22 to 28 per cent. Studies in the Central Provinces show on the other hand that the disease can be kept in check by spraying with Bordeaux mixture and treating the soil by Bordeaux mixture irrigation.

"*Bleached*" *Betel Leaves.*—In Bombay and Upper Indian markets, betel leaves are sold after they are 'bleached'. These

'bleached' cream-coloured leaves are in great demand and in many towns and cities are the ones that are used exclusively. Green leaves are therefore subjected to a 'bleaching' process. For this purpose healthy green leaves are first trimmed by cutting off their stalks and are then neatly arranged and tightly packed in large baskets lined with wet plantain leaves or gunnies. (hessian). The baskets are then kept in darkened but well ventilated rooms for several days and both temperature and humidity are regulated. The leaves gradually turn to a creamy colour but considerable decay also sets in. Every day the leaves are examined, those that have changed to the proper colour are sorted and taken out, and those showing signs of decay are also removed. The leaves do not colour uniformly and generally considerable green tint and spots of incipient decay and blackening are to be seen in these so called 'bleached' leaves. A good deal of experience is required in the work which is in the hands of trained men. It was found that 'bleached' leaves show a higher content of essential oils and possess also a higher diastatic activity. The leaves are generally sold at double the price of the ordinary green or unbleached leaves.

Chemical Composition.—Betel leaves owe their spicy burning taste to a volatile oil, which is a light yellow to dark brown liquid with an aromatic odour and which has a specific gravity of 0·958 to 1·044. The oil is a mixture of several compounds, the presence and proportion of which give the markedly different varieties of the leaves, their distinctive taste and aroma.

The chemical composition of the betel leaves as determined at the Betel Vine Station, Vellalur, is as follows:—

Moisture	... 76·00	Organic matter	... 87·92
Insoluble matter	... 1·72	Soluble matter	... 10·76
Iron and Aluminium	... 1·10	Lime	... 0·79
Magnesia	... 1·07	Potash	... 4·23
Phosphoric acid	... 0·77	Nitrogen	... 2·74

The leaves have considerable vitamins, both vitamin B and C, *viz.*, a vitamin B content of 9·365 and, vitamin C content of 4·800 milligrams per 100 grammes.

VI. HEMP (Cannabis Sativa).

VERNACULAR NAME: ALL VERNACULARS—GANJA, BHANG

The true hemp—Cannabis sativa—is grown on a small scale both in Mysore and Madras; it is grown not for the sake of its fibre, but for the sake of the highly narcotic resin product called 'ganja' which the plant yields. The drug is a monopoly of the Government and the cultivation is only to the extent that may be required by Government and is carried on by licensed

growers, who cultivate and prepare the product under the close watch and supervision of officials of the Excise Department.

In other parts of the world however, the plant is the source of an important fibre, the true hemp, as distinguished from the sisal hemp, sunnhemp and so on, also called European or Russian hemp.

Distribution.—Both as a fibre crop and as the source of 'ganja', 'bhangi', 'charas' which are the different narcotic substances obtained from it the crop is of very ancient origin. It occurs growing naturally or cultivated throughout the world over a wide range of climate, soil, and altitude, in Central Asia, Persia, China, Arabia, America and the table-lands of Brazil, even in northern Russia as far as Archangel, in England and Southern and Central Europe. In India it is cultivated from the sea level as in Bengal up to altitudes of 10,000 feet in the Himalayas.

Soil.—In Mysore the crop is cultivated on moderately clayey loams underlaid by porous sandy soils, chiefly on the river alluvium along the river banks in the Goribidnur neighbourhood. It is grown as the main crop of the year as it takes nearly five months to harvest and as the soil has to be well prepared in the preceding months. It is grown only under irrigation and its cultivation is of an intensive character as for the valuable garden crops. It is grown practically as the only crop of the year. It is only an occasional crop and may follow any of the numerous semi-irrigated crops or even rice which are common in this highly fertile tract.

Cultivation.—The field is thoroughly ploughed in the first good rains in the month of June and the ploughing is repeated several times; the ploughed field is again prepared by cultivators. The clods are broken by mallets and the field cleaned of stubble, grass and weeds, and sheep are folded on the land or cattle manure at five cartloads per acre is applied and the field well levelled. The sowing of the seeds in the ploughed field is done in the beginning of August. Shallow plough furrows are drawn at distances of four feet from each other and the seeds are dropped into the furrows and covered by an adjoining furrow. About five to eight pounds of seed are sown in an acre. The furrows are for the first time irrigated now. The seeds germinate and plants are seen above ground in about ten days. In about a fortnight thereafter the field is worked with the interculturing toothed hoes, both along and across the rows and the crop is thinned considerably. The interculturing between the rows is repeated twice at intervals of two weeks, and the field is also hand weeded. Irrigations are given about four to six times depending upon the extent and frequency of the rainfall, through the whole crop season. The crop grows thick and bushy and reaches a height of about 4 to 6 feet. About the month of

November the plants form flower heads and the most laborious part of the cultivation now begins.

The 'ganja' plant is dioeceous, that is, the plants bearing the male flowers are different from those bearing female flowers. As regards the 'ganja' resin which is the product for which the crop is cultivated, it is found only in the flower heads of the female plants. Furthermore the resin is formed only when these female flowers are not fertilised. If they are fertilised, then they merely set seed and are practically worthless as yielders of 'ganja'. The crop however is a mixture of male and female plants, and the work at this stage is to pull out the male plants as soon as they can be made out as such, so that there may be no male plants which may fertilise the female plants and thereby ruin the work of the year. To the extent male plants are allowed to remain by neglect or want of timely attention, to that extent the 'ganja' yield of the crop goes down. The field is therefore gone over repeatedly, thoroughly and closely inspected, and every male plant as soon as it can be distinguished. as male is pulled out and taken away and only the female plants are allowed to remain. The flower heads of these plants are soft as cotton to the touch if the fingers are passed over them, in case they are not fertilised, but feel rough and knotty if they have been fertilised. Many plants passed over as female turn out to be male and even with great care a certain percentage of the female plants is fertilised. Resin now begins to form rapidly in the unfertilised flower heads which become quite sticky to the touch. Rain at this stage is most damaging and is therefore greatly dreaded. About the middle of January the plants begin to yellow and are ripe to cut. The plants are harvested by cutting them at the base of the stem. They are removed to the threshing floor and the flower bearing branches are cut and arranged circularly on the floor, after which they are trampled over. The flower heads become pressed together and adhere firmly, in the form of a flat cake, owing to the gummy resin. The flat mass of 'ganja' is now cut into circular discs which weigh about a pound each and taken to the Government Treasury.

'Ganja' is the only product for which the plant is made use of. The male plants which are removed from the field in cart-loads and which can be made use for fibre are simply regarded as waste material and made use of as manure and as fuel.

Yield.—The yield of 'ganja' cakes per acre is about 250 lbs., in the average crop. A good crop should give 350 lbs; yields up to 425 lbs., are also obtained which is considered very high.

SECTION IX.

MEDICINAL CROPS

I. GINGER

VERNACULAR NAMES FOR GINGER: *Kannada*—HASISUNTI, *Tamil*—INJI; *Telugu*—ALLAM; *Malayalam*—INCHI; *Hindustani*—ADRAK.

The ginger plant is cultivated for the sake of its underground stems or rhizomes which is the product to which the name ginger is given. As a spice it is used in many articles of food, but to a larger degree it is used as a medicinal product.

Distribution.—The ginger plant has been cultivated from very ancient times and has been an important article of commerce also. It is regarded as native to Southern Asia where it has long been under cultivation and where it continues even at the present time to be an important article of cultivation. Ginger is cultivated over the greater part of the tropical and temperate zones. The chief countries of cultivation are India, the East Indies, China, the West Indian Islands notably Jamaica, North Africa and West Africa. In India it is cultivated throughout the country in practically every province. On a large scale it is cultivated only in South India, where the ginger from Malabar has been an important article of export to other countries. Other important centres are Surat and Gujarat in Bombay and Rangpur in Bihar. The plant thrives both at sea level and at high elevations of 3,000 feet, as in the Mysore plateau. It is grown up to elevations of 5,000 feet in the foot hills tracts of the Himalayas.

It is a crop which requires considerable shade and moisture, and good irrigation or a heavy well-distributed rainfall in the alternative. It is grown therefore in tracts of both moderate rainfall and of heavy rainfall, up to 90 or even 100 inches, as in Malabar and in the malnad of Mysore.

Soils.—It grows on a wide variety of soils, provided they are not alkaline or lack adequate drainage. It grows on sandy soils, sandy loams, clayey loams, the typical red loams, on the lateritic soils of Malabar and the black rich, clayey soils as are found under tank irrigation. Good drainage is however very important and suitable provision is always made for adequate drainage in whatever method it may be cultivated.

Rotation.—The ginger crop takes almost nine or ten months to be harvested and therefore forms the only crop of the year. Sometimes it may be left in the ground even for a second

season. Moreover ginger as grown in Mysore is cultivated in association with another crop which is to provide the necessary shade. In some villages it is grown under the shade of the plantains and in this case it is a regular plantain garden with ginger as the ground crop. Elsewhere, the shade is provided by the garden 'togare', which also is grown as much for its crop as for its shade. Another common shade plant is the castor oil plant of the much branching perenniel variety, sometimes called the 'tree castor'. In this case the principal object is the shade and the crop from the castor is not an important consideration. It can therefore be said that there are really two crops grown on the land, the ginger being however the main crop. The practice of growing the ginger under shade is not however universal; in fact, outside of Mysore large areas are grown without any shade at all.

The rotation for ginger is about the same as for turmeric. Irrigated ragi, maize, chillies and many other garden crops are rotated with it in the small scale garden cultivation, in which form alone it is generally cultivated in Mysore. In tracts of heavy rainfall, it is solely grown with the help of rain, and tapioca, sweet potato, chillies and various yams are the different crops grown in rotation with it in these tracts.

Cultivation.—For irrigated cultivation the soil is dug soon after the harvest of the preceding garden crop at the beginning of the hot weather to a depth of 18 inches and is allowed to dry in large clods. With the very first early rain about April, the clods are broken, dug again, weeds, roots and stubble removed and burnt and the soil brought to a good tilth. It is then heavily manured with about forty cartloads of cattle manure per acre, or even more, the manure is well worked in and then the field is laid out into beds for irrigation. The ginger plots are also surrounded on all sides with a good trench 18 inches to 2 feet deep and about 9 inches in breadth, for the sake of drainage and the prevention of water logging. The beds are all made ready by the middle of May, which is the season for planting ginger. The planting material consists of pieces of ripe ginger which have at least one good shoot or bud. Furrows are drawn in the beds with hand tools at distances of a span or nine inches and in these the seed ginger is planted by pressing it into the soil about two inches deep and at distances of six inches from each other. The bed is levelled and irrigated. At the same time along the irrigation channels seeds of garden 'togare' are planted, so that they are twelve feet from each other both ways. Instead of 'togare', castor seeds can be planted, or a few of the one and a few of the other may be planted. If the buds are vigorous, shoots may appear above ground in about ten days, otherwise it may take two or even three weeks for all of them to show above ground. The beds are hand weeded frequently and irrigated as required. Cattle manure is also given twice in

the course of three months. The plants grow to a height of about two feet, with several lateral and young shoots from the same clump. The crop becomes ready for digging about the month of December, when the leaves begin to yellow and the stems to dry and lodge on the ground. The harvesting may be done by digging out the whole crop or by digging only portions of the crop or by digging only portions of the clumps. The harvesting may not be done at all and the crop allowed to lie in the ground. All these enable the cultivator to remove the crop according to his needs or according to the prices ruling in the market.

Rainfed Cultivation.—Where it is grown as a purely rain-fed crop as in the malnad of Mysore and Malabar, the field is dug or ploughed deep and prepared in the usual manner and then laid into a series of long elevated beds of flat ridges divided by wide furrows. The ridges or elevated beds are made about 18 inches in height and two feet wide and as long as convenient. The beds are however cut by cross drains or furrows, which serve both as drains and path ways. The soil of the ridges is now manured heavily with cattle manure which is worked in and the beds then levelled. Seed ginger is planted across the ridges at distances of six inches each way. The planting is done well in advance of the heavy rains, and generally at the end of May or the beginning of June. The bed is now covered by a thick mulch of leaves, so as to prevent it from drying and later to break the force of the monsoon rains. Weed growth is not heavy under this leaf mulch, and it is left on until the severity of the monsoon is over. The crop is then weeded, and the beds mended as may be required. The crop becomes ready for harvest by December, when it is dug.

Seed Rate.—The quantity of seed ginger required varies a great deal with the distances of planting. Where the ridges are divided by wide furrows, the quantity is very moderate, but where it is grown in beds under irrigation in garden cultivation, the quantities are high. The quantity usually varies from 750 lbs. to 1,500 lbs. or even 2,000 lbs. per acre. Seed sets are generally very uneven in quality and this also accounts for the great variation in the seed rate.

Yield.—After the ginger is all dug out, it has to be thoroughly cleaned by washing before it can be sent out for sale. The rhizomes are not smooth and straight, but are rather rough and knotted and the clumps are composed of rhizomes adhering close together. All these conditions favour the inclusion of much soil and dirt in the clumps which have to be removed by washing, drying and rubbing between the hands. The ginger is given a light drying in the sun before being brought in. The yield of ginger as it is dug varies not only according to the method of cultivation and the season but also according to the condition in which it is dug whether somewhat tender or quite

ripe and rather dry. Under good garden cultivation some 7,500 to 10,000 pounds of ginger in moderately dry condition can be obtained per acre, though very high yields up to 40,000 pounds are also reported.

Dry Ginger.—A good deal of the ginger of commerce is dry ginger, which consists of ginger rhizomes peeled of their skin, well dried and bleached. Various methods are in vogue in different cultivating tracts for preparing the 'dry' ginger. The method adopted in the Surat district (Bombay) is thus described by Mollison; after the ginger is sun dried after digging and cleaned of adhering earth, it is soaked in water until the rhizomes soften somewhat and become easy of peeling. The skin is shaved off with bits of seashells, and the peeled rhizomes are well washed in water and put out to dry in the sun for three or four days. This bleaches the ginger and dries it. It is now rubbed between the hands and put out again in the sun to bleach and dry for another three or four days, after which the rubbing between the hands is repeated. The product is now steeped. in water for about two hours, taken out and dried in the sun till it is quite dry, rubbed on a coarse cloth to remove any last traces of the skin or dirt and stored as 'dry' ginger. This method of preparing dry ginger is slow but has the merit of preserving the fragrance and the essential constituents of the ginger almost in an undiminished condition.

Ginger can be and is, in some countries, cured much as turmeric is cured, that is to say by using boiling water to rupture the cells and render drying quicker and easier. In this method either plain water is used or water containing some milk of lime stirred in it. These methods give ginger of dark or poor colour.

The Malabar 'dry bleached ginger' is prepared in the following manner: Green ginger is put into large shallow brickwork cisterns or vats which are lined with cement and water is let in enough to stand a foot above the ginger; the mass is now carefully and uniformly trampled upon under the feet of coolies, during which operation the ginger is cleaned thoroughly of adhering earth and roots and partly deprived of its skin; the process is repeated with frequent changes of water, till the ginger is thoroughly peeled and cleaned. The peeled ginger is now removed and put into water containing lime stirred in it, the lime water having the consistency required for white-washing. After the ginger has remained in the lime water for some time, it is removed, drained and then brought into the sulphuring chambers. In these rooms which are about 12′ × 12′ × 12′ the ginger is kept in small wicker trays in shelves which are fixed against the walls about three feet one above the other. Sulphur is so burnt in the rooms that no smoke from the fire enters the room and only the fumes of the sulphur fill it. The fumigation goes on for twelve hours, after which the room is thrown open

and well ventilated. The ginger is then put out to dry in the sun for a day. It is then soaked in the lime water a second time and also fumigated with sulphur and then dried in the sun. The same three processes are repeated a third time, the fumigation being reduced to six hours. The ginger which is now quite bleached and white is thoroughly dried in the sun and then stored for sale.

The proportion of dry ginger to raw ginger varies from 16 to 20 per cent.

Botany and varieties.—The ginger plant—Zingiber officinale—belongs to the natural order Zingiberaceae, to which other important crops like turmeric, and cardamoms also belong.

The plant is propagated by means of the underground swollen stems on which are found 'eye buds' which send up shoots above the ground. The plant is perennial and though the above ground portions die out annually it continues to live through the undergound stems of which new ones are formed each year while the older portions decay and die off. The underground portions which form the ginger are thickned rounded stems about half to one inch in diameter, and are very much branched, there being the primaries, secondaries and tertiaries the last formed ones having young buds or shoots at the tip. A clump of rhizomes resembles in shape roughly hands and fingers, by which terms indeed they are sometimes known. The rhizomes have circular scars close to each other all along their length with minute scales adhering to them. The roots are fibrous and spring from the base of the rhizomes and traverse the ground to a depth of about nine inches to a foot with a narrow lateral range. The above ground stem is erect, unbranched and thin though slightly thickened at the base. It is formed of the sheating petioles of the leaves. The leaf blades are smooth, narrow and lanceolate, and are borne at about right angles to the stem. The plant grows to a height of about one foot to two feet. Flowers rarely appear on the ginger crop. They are of the type characteristic of this order of plants, the inflorescence being a spike springing from the underground stem, protected by imbricated concave bracts. The flowers are bisexual and possess the characteristic modified petaloid stamens, one of which alone bears anthers and a style with a funnel shaped stigma. Neither flowers nor seeds are commonly seen.

The ordinary cultivated variety is the only one met with. The so called 'mango' ginger which is cultivated on a small scale and used in pickling, on account of the peculiar mango flavour possessed by these rhizomes is however a species of turmeric—Curcuma amada,—and not a variety of ginger. Varieties can however be seen in Upper India, in which both the plants and rhizomes are much larger in size and the inside of the ginger itself somewhat light pink in colour.

Pests and diseases.—There are no serious pests attacking ginger. The shoot-boring insect (Dichocrosis punctiferalis, G.) the grub of which bores into the shoots of the turmeric and also attacks likewise cardamoms attacks the shoots of the ginger plant also, causing the shoots to wilt and die. The shoots and underground stems are also subject to the attacks of certain fly maggots similar to the pest on cardamoms. No remedies have been worked out, but the incidence of the pest and the damage are negligible.

A disease often causing serious loss is the 'soft rot' (Pythium gracile, Schenk) of ginger. Affected plants begin to become pale, and the tips of the leaves to yellow; wilting and drying up of the leaves follow. The fungus descends down into the base of the shoot which becomes soft and watery. The rhizomes themselves are next invaded and all the tissue inside the outer skin is reduced to a black soft putrefying mass. Affected plants do not produce any further rhizomes.

The disease is favoured by damp, and badly drained conditions, which are intensified in seasons of heavy rainfall, when alone it breaks out seriously. Infection occurs from infected soil and from infected seed. Treatment is only of a preventive character, such as the planting of healthy seed without any suspicion of any diseased origin, digging the whole crop of ginger at maturity and avoiding the planting of ginger in the same soil for several years, and the burning of all leaves and other diseased materials. In areas of heavy rainfall, the heavier soils inclined to become very wet in the monsoon should not be put down for ginger.

A leaf spot disease or 'Vermicularia' disease is sometimes seen on ginger. The leaf blades become covered with many yellowish and brownish spots, which develop and gradually dry up both the leaves and the shoots. Dusting the plants with quicklime is claimed to keep down the disease, but spraying with Bordeaux mixture is found more effective.

Chemistry and uses.—Like turmeric, arrowroot and so on, of this order, the dry matter of ginger rhizomes consists largely of starch; its special aroma is due to the volatile oil which is present to the extent of 2 to 3 per cent, and its pungent taste is due to the presence of a resin, found dissolved in the oil. The chemical composition of the raw ginger is as below:—

Water	*Albuminoids*	*Oil*	*Carbohydrates*	*Crude fibre*	*Ash*
81·0	2·3	1·0	12·3	2·4	1·2

Ginger is used as a spice in cookery and as a medicine. It is also prepared as an article of confectionary or preserve, sugared as crystal ginger, or preserved in syrup. It is pickled in salt and is used very generally in Indian homes. As a medicinal article, ginger is credited with curative properties in many digestive troubles. Dry ginger is indeed one of the three

important ingredients considered as the foundation of many Indian medicinal prescriptions, the other two being black pepper and long pepper.

II. SENNA. (Cassia angustifolia.)

VERNACULAR NAMES FOR SENNA :—*Kannada*-SONAMUKHI, *Tamil*-NILAVAGAI, *Telugu*--NELATANGEDU.

Senna, also called Tinnevelly Senna, is cultivated for the sake of its leaves which are used medicinally on account of their purgative properties. The plant is regarded as a native of Arabia, in the southern parts of which as well as on the opposite coast of Africa it abounds. The plant occurs in the Punjab and in Sind on waste land but is cultivated and grown in some parts of India, notably in the Tinnevelly district of the Madras Presidency and in parts of Bombay around Poona, where at one time it was a crop of considerable importance. Owing, however, to the small and fitful demand for the leaves on account of the increasing popularity of various salts with similar properties, the cultivation is only on a limited scale and confined practically to the Tinnevelly district. As a recent introduction in Mysore the crop has been found to do very well wherever tried. The plant is grown principally as a dry crop on dry land fields. To some extent it is sown on rice land immediately after the harvest of the rice crop, where it grows either depending entirely on the moisture left over in the soil, or is given a light irrigation, if available, somewhat in the way that green manures are grown. Very rarely, for instance, when there is a good demand, it is grown as a semi-irrigated crop, and as a subsidiary crop in young cocoanut gardens. The crop will not stand heavy irrigation.

The crop can thrive on a variety of soils, but is largely grown on red loams including even coarse gravelly soils, on alluvial loams and on the rich clayey rice fields. It is seldom seen however on the black cotton soils.

Senna is grown either as the main rainy season crop from the month of July onwards or in the later monsoon from September onwards. The crop occupies the ground for three months when only leaves are gathered and for another month to six weeks, if seeds are to be gathered also. Sometimes it is left standing for two or three years; and as it is a hardy deep rooted plant it is able to survive the hot summer months. It is however only in areas where no better crops can be grown and where the expense of annual cultivation has to be saved that it is left to struggle on in this way. The later sowing season, *viz.*, the month of September, will be found more convenient from the point of view of drying the leaves after they are gathered, while the July planting season (in Mysore) will be found better from

the point of view of yield. The land for senna is usually prepared roughly, and no fine clean tilth is attempted. The field is ploughed twice, harrowed and levelled and soon after a soaking rain the seeds are sown, generally broadcast; sowing in rows either in plough furrows or through drills will be a better practice. In the latter case the rows can be made one foot apart and the seeds sown fairly thin in the rows. About 15 lb. of seed will be required for an acre. The seeds have a hard and tough seed coat and a certain amount of rubbing with coarse sand so as to abrade the surface, which can be secured by pounding it lightly in a mortar with the sand, will be necessary for inducing even and quick germination. After the plants begin to grow, interculturing once or twice is given after which the rows close up. The plants do not grow tall but when the flower stalks begin to grow they elongate and become almost equal in height to the lower portion of the plant. It is usual at this time, that is, when the flower stalks begin to appear, to cut off the flower stalks; this has the effect of inducing further branching and perhaps of increasing the potency of the leaves. When the bulk of the leaves appear mature, which can be judged by the leaves becoming full grown, thick and bluish in colour, losing the tender green of the young leaf stage, they are stripped and collected. The plants are left in the field to yield a further flush of leaves and also to bear flowers and set seed. They are later on stripped again, and left in the field to be pulled out when the seed pods are dry. The leaves collected at the two strippings are spread on a clean floor indoors or, at any rate, under shade to dry. The layer of leaves is frequently stirred with the feet or by means of rakes so that the leaves dry uniformly. In a week or ten days the drying is complete and the leaves at this stage are of a yellowish green colour and are fit for sale. The pods are also well dried and beaten out to get the seeds. The yield of dry leaves from dry cultivation is about 700 lbs. and that from irrigated cultivation about 1,400 lbs. per acre.

Botany and Varieties.—The Senna—Cassia angustifolia—belongs to the natural order Leguminoseæ and the sub-order Caesalpiniæ. It is an erect, low growing, much-branched shurb seldom reaching more than two feet in height. The leaves are simple and pinnate and the leaflets are narrow, lanceolate and pointed, about $\frac{3}{8}$ to $\frac{1}{2}$ inch across at the middle and about 1^{2} to 2 inches in length. The leaves are thick and tough and when ripe are somewhat yellowish green in colour, and as marketed have a peculiar disagreeable smell. The flowers are brilliantly yellow in colour and are borne on a long slender stalk often 12 to 18 inches in length. The pods are flat and thin about $\frac{3}{4}$ inch wide and about 3 inches long. A closely related species, which is almost identical with Tinnevelly senna, is the Alexandrian senna, Cassia lanceolata, which comes from Arabia and East Africa and which often competes with the former.

Chemical Composition and Uses.—The senna leaf is esteemed as a safe aperient and is used in the form of a cold infusion or decoction in water either by itself or in conjunction with other aperients, the disagreeable odour being often masked by the addition of ginger, cloves, etc. The leaves owe their purgative property to the glucoside, cathartic acid.

III. AJWAN (Carum copticum).

VERNACULAR NAMES FOR AJWAN :—*Kannada*—OMA, OMAKKI ; *Tamil* – OMUM, ASAMADAM ; *Telugu*—OMU, OMAMU ; *Malayalam*—AYAMADAKAM ; *Hindustani*–AJWAN.

Omum or ajwan is one of the minor crops grown in many parts of India, principally for the sake of its medicinal value and to a smaller extent for use as a spice and flavouring agent. The plant is said to be a native of Egypt, but is grown in many countries in Central and Western Asia, such as Iraq, Iran and Afghanistan. The Indian acreage is estimated about 100,000 acres, the bulk of which is situated in Bengal. It is grown on a small scale throughout India and the best quality is said to come from Ujjain in Central India.

The crop is mainly grown in the plain country but can flourish and can be grown to perfection even at high elevations such as the plateau of Mysore. It is grown as a cold weather crop in the later rains, much like many of the black cotton soil crops, chiefly with the help of the moisture stored in the soil during the heavy rains. It is grown both as a dry crop and as an irrigated garden crop. In the former case the soils suitable are only the black cotton soils. The crop is grown mostly by itself but to some extent also as a light mixture in low growing crops like fenugreek or coriander. It grows to a height of about two feet and the umbels of flowerheads are borne on stiff branching stems above and quite clear of the low growing mixed crop.

Cultivation.—The field is well prepared as for a garden crop, by ploughing or digging, the clods are well broken, and weeds removed and the soil reduced to a fine tilth. The field is also heavily manured with cattle manure. Seeds at the rate of about 2 to 3 lb. an acre are sown by broadcasting in the moist soil and stirred in either by hand or with a light harrow. The seeds sprout in four or five days. Irrigation immediately after sowing has to be light and well controlled, so that the seeds do not float off and collect at the corners of the beds. The crop is given light irrigations regularly, and the beds are also weeded twice. The plants are thinned if necessary at the first weeding and the stand made uniform by thinning from the crowded parts and planting blanks or wide spaces. In two months the plants are in flower and the field looks at this time like an ornamental flower bed with the minute delicately small snow-white flowers borne in large umbelliferous clusters. Sown in October or early in November, the seeds ripen and become ready for harvest by

the end of February or early in March. The plants branch rather profusely and the umbels therefore mature unevenly; there is a considerable interval of time between the ripening of the first formed umbels and the later ones like the secondary and tertiary branches. When the bulk is ripe the plants are pulled out by the roots, put out to dry in the threshing floor and spread out on mats and carefully rubbed by the hand or feet to separate the seeds. A good crop will yield about 300 lb. per acre of seed. Grown as a dry crop on the black cotton soils, the cultivation is not so thorough or the soil so well prepared; the crop however makes almost as good growth as in garden cultivation and gives a moderate yield of about 200 lb. of seed.

Botany and Varieties.—The Omum plant—Carum copticum—belongs to the order Umbelliferea. The plants grow to a height of 2 to 3 feet with glaucous greyish green stems which branch freely. The leaves are sparse, compound, with the ultimate segments all linear. The umbels of the flowerheads are compound with bracts forming linear sometimes divided involucres. The flower are very small and white and in the mass very conspicuous and showy. The petals are keeled, and are five in number. The stamens are five and epigynous. The ovary is inferior and two celled and the fruit is composed of two indihescent carpels, ovoid and distinctly ridged, the seeds being very small. The flowers are visited by swarms of minute flies and bees. Although there seems to be only one variety under cultivation, the name 'ajwan' is sometimes applied to the closely allied species, also under cultivation which is 'Carum Roxburghianum.'

Chemical Composition and Uses.—The chief use of ajwan is for the sake of its medicinal value. Its effect is mostly as a carminative and as a stimulant. Colic, diarrhoea, flatulence and indigestion and such irregularities of the digestive tract are believed to be cured by ajwan in some form or other. It is advised even in the cape of cholera and 'omum water', is a good specific in the early stages. "Omum water" is a familiar preparation of the seed, which is made by distilling the seed with water and is really a dilute mixture of the oil from the seeds with distilled water. The seeds with a little bruising are used as an inhalatory like smelling salts in the case of colds. The seeds contain a volatile oil which is their essential constituent and amounts to 4 to 4·5 per cent of the weight of the seed. The chief constituent of the oil is thymol. The oil, on standing and cooling, deposits fine white crystals of thymol.

The seeds are used as a spice or condiment in many Indian dishes and are sometimes mixed with arecanut for chewing with betel leaves. Even as a spice, it is in most cases intended as much for its medicinal value as for its special flavour.

Trade.—Ajwan seeds form an article of export to a small extent. The quantity exported from India during the year 1939-40 amounted to 79 tons.

IV. BAJE OR SWEET FLAG—(Acorus calamis).

VERNACULAR NAMES FOR BAJE : *Kannada*—BAJE *Tamil*—VASAMBU, *Malayalam*—VASAMBU, *Hindustani*—BACHA.

The 'baje' plant is grown for the sake of its aromatic medicinal roots or rhizomes. In many parts of the world it grows wild as a water weed in the shallow margins of creeks, lakes and pools of rivers which do not dry up and along water channels which flow almost permanently. In Mysore it is grown as a carefully cultivated crop and receives much care and attention. The cultivation is confined to one taluk, *viz.*, Koratagere, and somewhat curiously, has not extended to any other part of the State, though in Koratagere itself the cultivation is very old.

The crop is grown in very much the same way as rice, in fields which are puddled and which are kept irrigated like a rice field. The crop occupies the ground for a whole year. It is grown both in clayey loams and on the light alluvial soils of river banks. The planting season is about the months of March—April but the crop may be planted almost at any part of the year. As the rhizomes have to be dried in the sun after they are harvested, it is a convenience to adjust the planting season so that the harvest may not fall in the months of heavy rainfall.

The fields are laid out exactly as for rice and with good water-tight low bunds for the impounding of water. In fact the 'baje' crop is rotated with the rice crop, or with any semi-irrigated garden crop which is grown without the need to remove the field bunds.

Cultivation.—The field is irrigated sufficiently to soften it for ploughing and after being ploughed twice is watered heavily and ploughed in puddle and left for a few days and ploughed in puddle again. It is now levelled by the levelling board over the puddled soil. The field is now heavily manured with the leaves of the 'honge' (Pongamia glabra) which are trampled into the puddle. In this condition the field is ready for planting.

The planting material is made up of the growing ends or tops of the previous crop of 'baje', much as in the case of the sugarcane crop. At harvest the mature portion of the rhizomes is cut off and this forms the marketable crop; the tender portion formed by the growing end is reserved for planting, like the tops of sugarcane. These tops can be planted at once or can be kept covered up with dry leaves or straw on the ground for about a week or ten days without being damaged. If they have to be kept longer, then they are kept in open pits, well moistened with water. At planting time these tops are slightly trimmed by cutting off and shortening the leaves at the end, and are planted in the soft mud by pressing about two

inches of the root end into it, the leafy growing end being well above ground. The planting is so done that this end slopes and points away from the direction in which the water enters and flow into the bed. This is done in the belief that it helps in making the rhizomes grow longer. The tops are planted in rows one foots apart and at a distance of one foot from each other in the rows, 'scissor' style, that is to say, the plants in the second row come in between the plants of the first row and not opposite to them; plants of only alternate rows are exactly opposite each other. The field is kept regularly irrigated and the level of water maintained as for rice, that is to say, at least a depth of two inches in the beginning and increased to four inches as the plants grow and lengthen. The field is also weeded several times carefully, and every time the growing plants are somewhat pressed down along their length into the mud, with only the leaves and a little of the stem growing erect. In the fourth month the field is manured with cattle manure; four cartloads are used per acre and are broadcast prior to the weeding. Weeding is given almost once a month and usually eight weedings are given during the whole period from planting to harvest. In about a year from planting the tops begin to become yellow and are ready for harvest. Water is stopped and the field allowed to dry somewhat retaining just enough moisture to make the digging easy. The digging has to be deep and is generally laborious and costly, as the rhizomes send down roots profusely which go down to two feet. After the plants are completely dug out, the tops are cut off and retained as seed for further planting. The rhizomes are about a foot or 18 inches in length and are now cut up into short lengths of about 2 to 3 inches, and all the fibrous root growth on these is cut away and the pieces then washed to remove all adhering earth and put out to dry in the sun. Five to seven days of good sun are required to dry the pieces thoroughly. The dry bits are now put into a rough gunny bag and rubbed down on the floor in order to free them of leafy scales which adhere firmly to them and also any further pieces of root that may have remained after cutting away. The produce is marketed in this condition. An acre of the crop yields about a ton and a half of dry marketable rhizomes and a very good crop may yield up to double this quantity. The price of the article fluctuates a great deal and has ranged from Rs. 2 to Rs. 6 a maund (25 lbs.). It is a very remunerative crop but the demand is not large.

'Baje' is remarkably free from insect pests and diseases. It is considered a valuable medicinal article and is used in the treatment of intestinal worms, the bites of poisonous reptiles, foul breath, throat affections and so on.

It also forms the main ingredient in many insect powders used to protect clothes and are put into clothes cup-boards. It also enters into the composition of face powders.

SECTION X

DYES

I. INDIGO.

VERNACULAR NAMES FOR INDIGO—*Kannada*-NILI, *Tamil*-AVARI, NILI, *Telugu*-NILI, *Malayalam*-NILAM, *Hindustani*-NIL.

Distribution.—The famous blue dye, indigo, was for centuries being derived only from the vegetable kingdom as a natural product. Though many kinds of plants yield the dye and were in cultivation for this purpose in many parts of the world, the bulk was being derived only from the indigo plant—Indigofera tinctoria—which was the plant being cultivated in India for this purpose exclusively. The advent of the synthetic indigo dye has made the cultivation of the indigo yielding plants for natural indigo quite unprofitable and it has therefore been almost completely given up. In India the cultivation still lingers here and there and whenever supplies of synthetic indigo become scarce owing to wars or other circumstances (as it happened, for instance, during the Great War of 1914-1918) both cultivation and manufacture are resumed on a large scale. For example, the acreage in Madras jumped suddenly from 55,000 acres in 1913-14 to 460,000 acres in 1916-17. Next to the province of Bengal, South India was the most important tract of cultivation. The Northern Circars, the Ceded Districts, and the districts of North and South Arcot, Chingleput and Tinnevelly were the largest producers and in Mysore it used to be cultivated in the villages of the Chikaballapur, Bagepalli, and Goribidnur taluks of the Kolar district, in the villages of the Maddagiri taluk of Tumkur, and in the villages of Belakvadi, Yalandur and others bordering on Coimbatore. In the days prior to synthetic indigo, the indigo plant was being cultivated as an important commercial crop in many of the tropical countries such as the Philippines, Java, China and the East Indies generally, in the eastern and western coastal belts of Africa, in Mexico, Guatemala, Nicaragua and other parts of Central America, and in the West Indies.

Soils.—The indigo crop is grown both under irrigation and as a dry crop. It is grown on the somewhat clayey soils on which rice is usually grown; it is, as a matter of fact, grown as a rotation crop with rice. Under irrigation the lighter alluvial types of soil are also put under indigo. As a rainfed crop it is grown both on the black cotton soils and on the red clayey loams. It is claimed that the crop grown on the lighter types of

soils yields a better and larger outurn of dye than that grown on the heavier types and the black cotton soils with much admixture of lime in them but that on the latter types of soils the crop itself is heavier.

Rotation.—The crop is grown both in the rainy season from July to December and also in the hot weather from January to April. It is generally grown pure; this is especially the case when it is grown in rotation with rice on the rice fields. When grown as a purely rainfed crop it is sown either pure or in mixture with some grain crop like jola or 'sajje'. When grown under irrigation it is attempted to be grown mostly with the help of the moisture left in the soil after the rice crop is harvested, and irrigation is given only moderately, later on. As a rotation crop it greatly benefits the succeeding crop of rice or other grain, as it is a leguminous crop and the root nodules are profusely developed. Moreover the water in which the plants have to be steeped for extracting the dye in the process of preparing the dye, is drained off after the dye has settled and is allowed to flow on to the rice fields where it acts as an excellent fertilising material and increases the yield of the rice crop. So greatly is this liquid—called 'seet'—esteemed that much of the fertility of the rice fields in such tracts is attributed to it.

Cultivation.—The soil for indigo is well prepared by repeated ploughings and is later worked with the bladed harrows or toothed cultivators. Weeds and stubble are gathered and burnt and the field is then harrowed. Indigo seeds are usually prepared for sowing by mixing them with coarse sand and pounding the mixture lightly in a mortar with a wooden pestle. The hard seed coat is by this process very much abraded. If sown without this treatment the germination is exceedingly slow and uncertain. Prepared seed is sown broadcast at the rate of about 10 or 12 lb. per acre on the rice fields and is harrowed in and the field is then irrigated. On dry land after the field is prepared in the above manner, the seeds are sown generally in drills about 18 inches apart, alternating with two or three rows of jola or 'sajje' at distances of about six feet. The sowing on the dry lands is from July to September and that for the irrigated crop is from December to February. The crop is weeded or intercultivated about three weeks after it comes up. The plants begin to flower in about 2½ months after sowing. At the flowering time or even a little earlier when the crop has attained a good leaf growth, the plants are cut for preparing the dye. Every two months or six weeks after the first cutting a second or third cut can be taken. Not more than two such ratoon cuts can be taken in practice either because the field has to be freed for the next crop or, in the case of a dry crop, the season is finished. The cutting is made four inches above the level of the ground leaving enough stubble to grow for the second cutting. These cuttings consisting of the leaves and branches with all the leaves intact are taken

immediately to the steeping vats for the extraction of the dye.

Preparing the Dye.—The method of extracting the dye consists of several processes, *viz.*, 1. Steeping the leaves and branches in water under a certain amount of pressure so as to dissolve out the products which later on yield the solid dye, as the result of sufficient aeration. 2. Drawing out this water from the steeping vats, free from the bundles of the cuttings, and stirring it vigourously so as to aerate or oxidise it and make the dye separate out, in solid granules and settle to the bottom as a slimy deposit. 3. Separating this sediment or deposit from the spent liquor or 'seet,' boiling or heating it to induce further granulation and then filtering out the liquid through cloth. 4. Moulding the dye in small blocks and drying them slowly.

These various processes are carried out in practice somewhat as described below:—The indigo vats or cisterns and the boiling house are constructed very near to a well or water source, where ample water may be easily available. All vats or cisterns are good masonry structures with a hard watertight well-cemented floor and sides. An ordinary unit of vats or cisterns consists of (1) a 'steeping' vat, which is an open rectangular masonary cistern generally 25 feet long, 20 feet broad and 4 feet deep. This is usually divided into two cisterns by a dividing wall. Over the partition wall and over the part of the lengthwise walls runs a channel for leading water into the cistern from a well or overhead tank; (2) at a lower level, that is, two feet below the bottom of these cisterns is another similar cistern, somewhat smaller, about 25 feet long by 15 feet broad. This is called the 'beating' vat. Holes are provided at the bottom of the steeping vats, through which the steep can be drawn into the 'beating' vat below. Likewise holes are provided in the 'beating' vat also for drawing out the spent liquor after the dye has settled down to the bottom; these holes are made at two levels, for convenience in drawing out the liquor as it clears; (3) lower down and situated usually inside the boiling house is another masonry or wooden tub into which the slimy sediment can be transferred; (4) inside the boiling house are (*a*) acopper boiling vessel, cylindrical in shape and about five feet deep and three feet in diameter, fixed over a fire, (*b*) straining arrangements for removing the water completely from the sediment and (*c*) a press for moulding the dye into small blocks. Variations are also seen both in the shape and in the size of the steeping vats. Thus in parts of the Northern Circars these vats are circular in shape. Rectangular vats are also made smaller than the size mentioned above and measuring $15' \times 12' \times 3\frac{1}{2}'$.

Extraction of the Dye.—For the extraction of the dye, the cuttings are brought in bundles to the steeping vat and arranged inside, so as to fill the cisterns up to three feet from the bottom; the bundles are pressed down by means of poles and wooden logs

which are placed over them and kept in palce by grooves cut in the walls. In the smaller vats, large stones are used for weighting down the bundles. Water is now let into the vats until the bundles are fully covered and the water stands at least six inches above the layer of cuttings. The steeping is allowed to go on for about twelve hours, the vats being filled in the evening and the steeping stopped in the morning. After the steeping is over the water is drawn into the lower or beating vat; the bundles are taken out and the steeping vat is well cleaned and got ready for another charge. After the steep is drawn into the beating vat, the liquid is vigorously agitated in order to induce aeration or oxidation. For this purpose two sets of three or four men stand in the cistern opposite to each other in two rows and by means of wooden oars or paddles beat the liquor towards each other, ladling it also up and down frequently. If the liquid tends to froth up, a little castor oil is poured over the surface which keeps the frothing down. Under this strong agitation the liquid rapidly changes colour which intensifies as the process goes on, and fine grains of blue sediment also separate out. As soon as the liquid assumes a deep blue or purple colour, the beating is stopped and the grains of the dye are allowed to settle. To aid the granulation a little lime water is sometimes stirred in. The clear supernatent spent liquid is now drawn off in two stages, until the sediment is free from seet as far as possible; the sediment is now drawn into the small cistern or tub by squeegeeing and a little washing. The sediment is all transferred to the boiling vessel, to which further lots are added as they come in every day until the pot is almost full. It is then slowly heated, principally with the object of aiding the granulation and making the grains firm; the heat is stopped when the dye assumes the characteristic deep purple colour which is desired in the product. The next process consists in pouring the charge over a blanket spread over a frame or resting on sand, a kind of primitive counterpart of a filter press. The excess of water now drains out or is absorbed by the sand. The soft mass of dye, now deprived as much as possible of the water mixed with it, is scraped and put under a special press, where it is moulded into little cubical blocks of about two inches in the side. These cubes are then taken to a drying chamber, generally inside the dwelling house, where they are lightly covered over and dried in the shade slowly.

Yield.—The produce of an acre including the two cuts when grown as a dry crop is estimated to yield about 25 lbs. of the dye on the average. With irrigation and good manuring yields up to 60 lbs. per acre are obtained.

Chemistry of the Dye.—Indigo as it comes into the market is of varying grades in respect of quality. The quality of the product depends upon the content of 'indigotin' in the material. This may vary from as high as 90 per cent in the best samples to about 60 and 65 in good samples down to 20 per cent and even

less in poor samples. The variation is due as much to the methods of manufacture and the species of the plant cultivated as to the wilful adulteration of the product with fine clay (which is the commonest adulterant).

The natural indigo contains along with 'indigotin' a mixture of at least three kinds of indigo, called indigo blue, indigo red and indigo brown, and sometimes even traces of a yellow colour; this mixture gives natural indigo an advantage over the synthetic product which is pure 'indigotin.' The product as it exists in the plant is not the dye, indigo, but a glucoside called 'indican,' which is soluble in water and therefore is extracted by the steeping water and which on oxidation is converted into the dye 'indigotin.' The 'indican' is contained in the leaves of the plant and good samples of the leaves will contain about 3½ per cent of indican on the dry weight.

Botany and Varieties.—The indigo plant belongs to the order Leguminoseæ, sub-order Papilionaceæ and is classed in the genus Indigofera. There are many species which are cultivated in different countries although Indigofera tinctoria—the species grown in India—is the one which is grown largest. The other equally important dye-yielding species are the following:—I. Sumatrana, Gaert.; I. arrecta Benth., also called Natal Indigo or Natal-Java indigo, which is largely cultivated in Java and yields the indigo classed commercially as Java indigo; I. anil; I. leptostachya D. C. also called Natal indigo; I. disperma (or "Guatemala" indigo which also yields Java indigo;) in addition are also some unimportant species.

The dye is also to be had from other plants such as Tephrosia tinctoria, Polygonum tinctorium, Amorpha fructosa, Nerium tinctorium, etc. In recent years the species I. Sumatrana, grown largely in Java, has been introduced into India as a superior variety yielding a large quantity of the dye.

The I. tinctoria is a small much-branched shrub growing to a height of two to three feet with thin wiry stems and branches. The leaves are pinnate and are from one to three inches in length while the leaflets are about one inch in length and ½ inch broad and oblong or oblo-lanceolate. The inflorescence is a raceme about four inches in length. The flowers are very small about ⅙ inch in length and light pink in colour; the calyx teeth triangular, acute and the standard pubescent on the back. The pods are 1¼ inches long and thickened on the suture.

Pests and Diseases.—The indigo plant is not subject to any serious pests. Leaf eating caterpillars of different kinds of moths are occasionally seen and a red and white spotted weevil (Alcides bubo, F.,) is also found sometimes breeding in the tender shoots, but neither does much damage. A pest of some importance which is specific to the indigo crop is a small light brown jumping bug (Arytaina punctipennis, Cr.). The bugs attack the tender growing shoots on which they settle in hundreds and suck the

sap; the leaves shrivel up and form twisted knots at the end of the stem; the shoot eventually dries up. The damage is not generally severe and can at any rate be controlled by pruning away the affected shoots and by spraying with contact poisons.

The indigo plant has been found to be a host plant to the "bacillus solanacearum" attacking potatoes, brinjals, tobacco, etc. The plants are also subject to a kind of 'wilt' which has been attributed variously to a deficiency of phosphates in the soil, and to a lack of aeration round the roots.

Acreage and production.—The total area in recent years has been very small, and for the whole of India has varied between about 38,000 and 60,000 acres. The major areas grew (1937-38) the following acreages;—Bihar—1,400; Madras—23,200; Punjab—11,300; the United Provinces—2,600.

The total annual production has likewise varied from 6,600 cwts. to 11,000 cwts. of the dye.

II ANNATTO (Bixa orellana)

VERNACULAR NAME FOR ANNATTO: *Kannada*—RANGAMALE.

A plant cultivated to a small extent in Mysore for the sake of the dye which it yields is the annatto or 'rangmale.' Like many other natural dye-stuffs, it has lost its importance after the advent of the coal tar dyes but is nevertheless grown here and there to a small extent, as a demand arises for it occasionally. The annatto has been a dye of considerable commercial importance in the past and was being cultivated in many parts of the world on a fairly large scale. Even now the dye is a well recognised commercial product and is in demand for some special purposes, such as the colouring of butter and other edible products; the plant therefore continues to be cultivated, though on a very small scale. The annatto plant is a perennial shrub which grows into a small sized tree as it becomes older and therefore belongs to the class of permanent crops. The chief countries where it is cultivated are French Guiana and the warmer parts of South America, the West Indies, West Africa, the East Indian Archipelago, besides many parts of India itself. In Mysore it is grown in small patches of a few bushes in many gardens and round about the quarters of the labourers and others on coffee estates, where it may often be seen growing wild. The only place in Mysore where it is grown on a field scale is around Closepet, Bangalore District, where it is grown as a semi-irrigated crop in fields and gardens on the banks of the Arkavati river.

The soils on which the plants thrive are the lighter types of loams and the red loams somewhat inclined to be clayey but which are well situated for drainage. The fields for raising the

crop are given a rough ploughing in the early rains of April and left to weather in a cloddy condition throughout the hot weather. With the rains of June and July the land is ploughed again and then shallow pits are dug in the ploughed field about 9 inches deep and one foot in diameter, at distances of six feet from each other both ways. The pits are filled with the well-weathered soil from the ploughed field and is also manured with a little cattle manure. In the middle of the month of July or early in August seeds of annatto are sown in these holes at the rate of three or four in each. In the alternative, nurseries may be raised in the early part of the year and seedlings may be transplanted. It will be found that with the six feet spacing, the plants become too crowded in three or four years. It is nevertheless allowed to grow in this way, with the bushes in close contact with each other, but later on at least, it will be quite necessary to thin and open out the growth by cutting away every alternate plant. The growth is however so vigorous that the plants branch out profusely and become very bushy. The field is kept cultivated with ploughs or harrows to remove weeds, as long as it is possible to work these implements. After the rains stop and in the following hot weather the field should be irrigated whenever the plants appear to droop, or the pits should be hand watered. In the second year after planting the plants begin to flower about the months of August and September and a small crop can be picked from December onwards. The plants continue to flower for about three months and the harvesting of the pods likewise goes on continuously till about the month of May. In fact flowers, young pods and mature ones may all be seen at the same time on the bushes. The plants make rapid and extensive growth and the crop goes on increasing year to year. It is left on the ground for seven or eight years and then cut and removed. If desired, the plants can be retained longer; they grow up into moderate sized trees about twelve feet high with an evergreen shady canopy-like crown and a stem some five or six inches in diameter.

The harvesting consists in the gathering of the pods when they are ripe and are beginning to split and when, as a matter of fact, many have already split on the bushes. Each day's picking is spread out on clean mats to dry in the sun and is allowed to dry until all the pods split and are quite dry. The splitting is also hastened by beating the seeds out of the pods. The empty pods or shells are then raked off and removed and the seeds are carefully gathered. The seeds are generally marketed as such and no dye is made by these small growers. Where however the crop is grown on a large scale the dye is made by the growers themselves and sent out for sale. The yield is about 7 to 10 cwts. of seeds per acre. Annatto seeds from Mysore are sent out usually to the dying and weaving centres like Adoni, Raichur and other places outside Mysore.

The dye itself is contained in the outer coat or layer on the seed, which consists of a tough firmly adhering pulp of the colouring matter and which adheres to the hands like a fine dust and stains them red or yellowish red, when the seeds are being handled. For preparing the dye, the seeds are soaked in hot water to loosen the layer of the dye, are lightly pounded to free them completely so that the dye comes off from the seed. The thick liquid with the dye in it is now poured off from the spent seeds and is allowed to stand so that the dye may settle to the bottom. When all the dye has settled, the liquid is decanted away or strained through cloth. The sediment which is the commercial dye is brought on to shallow trays and dried in the sun.

SECTION XI.

SPECIAL PRODUCTS

I. MULBERRY (Morus alba) AND SILK

VERNACULAR NAMES FOR MULBERRY:—*Kannada*-HIPNERLE; *Tamil*-MUSUKATTE; *Telugu*-RESHME CHATTU; *Hindustani*-SHATUT.

The cultivation of the mulberry plant is undertaken for the sake of its leaves, which are required for the feeding of the silk-worm. The cultivation forms an integral part of the sericultural industry and may, indeed be said to be the most important and fundamental part of it. The cultivation is therefore taken up only in countries and tracts where the rearing of the silkworm is carried on. The crop is thus of practical importance only as part of sericulture and, in tracts where on account of the climatic conditions the silkworm cannot thrive, the usual factors favourable or otherwise for the cultivation of the mulberry cease to have any importance. The main silk-producing or sericultural countries of the world are, Japan including Korea, the Chinese Empire, Asia Minor, Persia, India, Italy and Southern France. In India, the industry is confined to the State of Kashmir, parts of Bengal, the southern and eastern districts of the Mysore State and the adjoining taluk of Kollegal in Coimbatore. It is therefore only in these parts of the world that the mulberry is cultivated. There is no doubt that the plant can grow and flourish in many other parts of the world but this aspect of its cultivation has no practical importance. It may however be stated that a cold or sub-tropical climate is required for the crop and, if attempted in the tropics, only the cooler tracts with an average temperature not exceeding 80° will have to be selected.

The mulberry plant may be regarded as native to the Himalayas, on the foothills of which extending from Kashmir to Assam and up to an elevation of about 6,000 feet it occurs wild and grows with great luxuriance. In these tracts it also occurs in many diverse forms or varieties, the habit of growth varying from a dwarf bush to a large well-grown tree. The tree form grows extensively in Kashmir where even the cultivated form is the tree mulberry. Under cultivation, the mulberry is grown in one of three forms *viz.*, as a bush, as a tree or as an intermediate form which may be called high bush. It is propagated from seeds or from cuttings or by means of grafting and budding. It is grown either as a purely rainfed crop or under irrigation like a garden crop. When once the crop is planted it is allowed

to occupy the ground for several years, usually up to 15 years. Grown as a tree however it is practically a permanent crop and is kept on almost indefinitely. In whatever form it may be grown, whether as a tree or a bush or a high bush, the crop is subjected to regular and periodical pruning, in addition to the stripping of the leaves, and different systems are adopted depending upon the variety of the silkworm reared and the peculiarities of local customs.

Soils.—The mulberry can be grown on a variety of soils. Fertile deep red loams, well drained garden loams, black clayey loams such as are found under tank irrigation, fertile tank bed soils and the black cotton soils, are all put under mulberry. Very light sandy loams or sandy soils and those with a large admixture of coarse gravel or stones and soils with little depth are not suitable. When grown under irrigation, adequate drainage should be provided, as otherwise the crop suffers in growth and is also subject to disease. In many situations under tank irrigation, where mulberry is grown, drainage is lacking and much improvement can be brought about by providing suitable drainage. On the fertile clay loams under irrigation and on the black cotton soils under rainfed cultivation, the growth is generally luxuriant. In Mysore, the general type of mulberry soils is the ordinary predominant red loam; the next in order come the clay loams under garden cultivation and under tank irrigation; and next again come the black cotton soils. The last type is mostly confined to parts of the Mysore district, and on these the crop is raised as a rainfed crop. The first or red loam type, especially in the Kolar and Bangalore districts, is somewhat stiff and hard to work and often contains a considerable admixture of small lateritic pebbles. They require to be dug and frequently manured with heavy organic manures to keep them sufficiently mellow for the roots of the crop. As a matter of fact, a favourite form of organic manure in these tracts is wool waste purchased from the woollen mills in Bangalore and carted long distances to the villages in these tracts.

Planting.—The preparation of the soil for mulberry is very thorough, whether it is to be raised as a dry crop or as an irrigated crop. The ground is generally dug to a depth of one foot soon after the N.E. monsoon rains are over and the clods are allowed to weather through the hot weather following. If the area to be planted is large as in the case of rainfed cultivation, then the ground is ploughed several times instead of being dug, although even in dry cultivation, if the area is small, the ground is dug. It is essential that the conditions should be made favourable for the deep rooting of the plants. The clods are broken, the old roots, stones, gravel, etc., are removed and the soil brought to a clean well tilled condition. Cattle manure is now applied at the rate of 25 cart-loads per acre and ploughed in. Similarly, sand, red earth and tank soil or silt are also carted and mixed with

the ploughed soil, according as one or other may be required and may be available.

The planting of the mulberry consists in the putting in of cuttings, usually. It is according to one of two methods *viz.*, the pit system and the furrow system. The furrow system is adopted usually under irrigated cultivation and the pit system in the case of both irrigated and dry cultivation. In the latter case, however, the pit system is always adopted. When the planting is to be in the furrow system, large furrows are made in the prepared field about nine inches apart; water is let into these furrows and the soil well moistened and then the cuttings are stuck into the soft mud in pairs at distances of four inches between one set of two cuttings and another. The cuttings are usually about 10 or 12 inches in length and are planted in such a way that about 9 inches of the length containing two buds is showing above ground. The planting is usually made in the months of April and May which is the time when bushes in the older fields are given the annual pruning and are cut down to the level of the ground for starting new growth and when therefore branches are available in plenty for being cut and planted. Planting in these months which are generally rainless is possible only in the case of irrigated crops, as water for irrigation in sufficient quantities is necessary both for planting and for the frequent irrigations required in the early stages of the growth till the plants are well established. In this system the planting is very close and an acre will require between 70,000 and 80,000 cuttings. This makes it rather expensive.

Where irrigation water is not plentiful or is expensive, as in the case where water has to be lifted from wells, river channels or running streams, the furrow system gives place to the pit system, which facilitates hand watering from pots. In this system, after the ground is well prepared, pits are made in the form of irrigation basins about one foot in diameter and nine inches in depth and at distances of 1½ feet from each other, in the rows which are themselves made 2½ feet apart; the pits are thus 2½ by 1½ feet apart. The soil is first moistened by hand watering, and cuttings are planted at the rate of three in each pit. At this rate an acre will require between 30,000 and 40,000 cuttings.

In dry land cultivation it is almost the general rule to plant only in the pit system. These are made somewhat farther apart than in irrigated cultivation and are usually about 2½ by 2½ feet apart; this distance makes it convenient for the use of the plough or bladed harrow in cultivating the field between the rows both along the length and across. The season for planting in this case is about July, when the S. W. monsoon has quite set in and the ground is moist enough for planting. As rains occur at frequent intervals from this time onwards, the young crop has a good chance of becoming well established.

In irrigated cultivation whether in the pit or the furrow system, the field is laid out with suitable cross bunds into convenient beds for irrigaton. The cuttings begin to root quickly and the growth of branches from the eye-buds is also quick. With ordinary cultivation and regular irrigation the bushes attain a height of some 2½ feet within the first six weeks. The space between the rows and within the pits is well hand weeded, or in the case of dry land mulberry, interculturing harrows are used to work in the interspaces both lengthwise and crosswise and close to the rows. In ten weeks the bushes attain a height of 3½ to 4 feet in the case of irrigated cultivation and the leaves are now ready for the first picking. In the case of the rainfed crop, the growth is slower and the first picking may not begin until some four months are over, the earliest may perhaps be about twelve weeks.

Picking the Leaves.—The gathering of the leaves is in two ways. In one method, which is very prevalent in the Kolar and parts of the Bangalore districts, the bush is cut close to the ground, so that the leaves are gathered with the branches, *i.e.*, both twigs and leaves. These are taken home and the leaves are stripped and fed to the worms. After every such cutting down, the field is either ploughed or more generally dug between the rows and then irrigated. The bushes burst out into branches and leaves very quickly and within six weeks growth is sufficient to permit of a second picking of leaves in the same manner, that is, by cutting down the branches. Some five crops of leaves are taken in this manner during the year and between every two crops the field is given cultivation by digging. It is usual in these tracts to apply wool waste as manure about the middle of the season at the rate of two cart-loads per acre.

In a second method of gathering leaves, only the leaves are removed and the bare branches remain on the bushes and grow and branch out to give eventually a second crop of leaves. The bushes are stripped again and again in this manner and in irrigated cultivation about ten such pickings may be gathered, while in rainfed cultivation some six or seven. Sometimes picking may not be so selective and the year's growth may be gathered in five pickings. In this method of gathering the leaves alone, at the end of the second year the bushes are pruned or cut down to the level of the ground and thereafter this operation is repeated at the end of every year, so that the bushes are pruned only once in the year as against the five or six times in the first method. This method is common only in the row planting system of cultivation. Each method has its advantages and disadvantages but the force of custom plays a great part in favour of one or the other. The row system is more expensive in respect of the number of cuttings required per acre, it gives leaves which are somewhat thin, tender and papery and the plants are

too crowded without adequate aeration among the bushes. On the other hand, the pit system is more expensive in respect of weeding, as the garden has to be given diggings and hand weedings; it is also more costly in picking, as the branches have to be stripped, whereas in the row system whole branches are cut down. In the row system the leaves can be kept for some time as they are on the branches whereas the leaves from the pit system become wilted and flaccid very soon as they are detached from the branches and loose. In the row system there is also some wastage of leaves as mud and dust are splashed on to the lower leaves which have to be rejected on that account. The row system is favoured very much by Muslim cultivators as it permits of more in-door work in which the women who are *gosha* can take a greater part; otherwise paid labour will have to be employed for gathering the leaves by stripping in the field.

In gathering leaves for feeding to the worms, consideration should be given as to the best time for gathering and the best method of gathering. The leaves continue to assimilate and build up products within them as the result of photosynthesis as the day progresses, and it has been found that they contain the maximum quantity of carbohydrates about 2 P.M. and that this maximum is maintained till about 5 P.M., after which it diminishes very considerably and reaches a minimum about 5 A.M. The best time for plucking will therefore be the evening, when the leaves contain their maximum carbohydrates and are therefore of the highest feeding value. The manner of gathering the leaves is also of importance. As already stated, leaves may be gathered by (1) the removal of whole branches or the shoots only and (2) picking the leaves only. When whole branches or shoots are removed, there is firstly no selective gathering, so as to suit the quality or age of the leaf to the age of the worms and secondly, great injury results to the bush itself in which the branches and leaves become progressively small and tender, a condition which leads to poor quality of cocoons. The only advantage is a saving in labour. The best method is therefore to pluck only the leaves. From the point of view of the health of the bushes, it will be advisable further to gather only the blades of the leaves in preference to removing them together with the stalk either whole or in part. The stalks are only wasted in the feeding trays but if left on the bush add to its strength. Once the leaves are gathered with so much care, it will be necessary to see that they do not lose quality by being badly stored. Heating, fermentation and undue driage are to be guarded against and this can be best effected in practice by keeping the leaves in small loose heaps of not more than 1½ feet in height and by seeing that the room is kept quite cool. If necessary, a piece of cloth or gunny bag which is always kept moist may be hung nearby in the room.

Manuring.—The mulberry crop is usually well manured. The application of the manure is at the beginning of the crop season, after the field has been dug and the bushes pruned. As already stated, in some districts a further manuring is given in the middle of the season. The manures in general use are cattle manure including the manure of sheep and goats, tank silt, wool waste and silkworm litter from the rearing house. The last is not separately used but is thrown on the manure heap, where it mixes with the cattle manure and rots well before it is carted to the field with the cattle manure. The quantity of cattle manure used is 40 cart-loads per acre, if nothing is used in addition; otherwise 20 cart-loads are used and supplemented with 50 to 100 cart-loads of tank silt. Where wool waste is used in addition, this is at the rate of two cart-loads per acre.

Experiments on the manurial requirements of mulberry conducted in Mysore indicate in a broad way that the crop responds best to nitrogenous manuring, both in respect of quantity and of quality of leaves. A mixture consisting of 275 lbs. of groundnut oilcake and 125 lbs of ammonium sulphate has been found to be a profitable dose to apply per acre, in irrigated cultivation. Comparisons were made of this mixture against other manures supplying the same quantity of nitrogen (*viz.*, 50 lbs. per acre) such as cattle manure, ammophos, green manure, 'honge' oilcake and silkworm litter and it was found that the mixture gave about 15 per cent more leaves and of better quality than any of the others. The mixture should be applied in two parts, one-half being given at the beginning of the season and the other half about the middle.

Yield of Leaves.—The yield of leaves from the bush mulberry in Mysore, whether the bushes are grown in the pit system or the furrow system, depends mostly on the supply of moisture in the soil and upon the manuring and general cultivation. There is not much difference as between one method and another. Yields may therefore be classified only as between rainfed and irrigated cultivation. Thus, in the Mysore State the following yields are obtained:—

From rainfed crops: between 4,000 and 5,000 lbs. in some tracts and between 6,000 and 7,000 lbs. in some other tracts.

From irrigated crops: (1) under tank irrigation, 7,000 to 9,000 lbs., (2) under irrigation from shallow wells, 9,000 to 11,000 lb., (3) irrigated from deep wells with abundant supplies, 10,000 to 12,000 lbs.

As mulberry leaves are of value only as food for silkworms, it will be useful to express the yield in terms of silkworm cocoons. According to Mysore experience with the multivoltine worms, the quantity of leaves required for producing a pound of cocoons varies from 12 to 17 lbs. of loose leaves. The yield of cocoons per year in these different kinds of cultivation varies from 300 to 900 lbs. per acre.

Tree Mulberry.—The system of growing mulberry in the form of low bushes described above is almost the universal system in South India and in Bengal. In the State of Kashmir and in foreign countries the more general system is to grow it as trees. To a small extent this has been introduced into Mysore. The mulberry can grow into a tree some 40 feet in height but it is kept down by pollarding the branches within a manageable height of about 15 feet, the trunk itself being about 7 or 8 feet high and the canopy about the same height above. It is claimed in favour of the tree mulberry that the cost of maintaining is very much less, that more leaves are obtained, that the quality of the leaves is superior, that ground crops like ragi or ground-nuts can be grown in the plantation, and that the trees can be kept on permanently, irrespective of the price of silk and the paying nature of silkworm rearing. For raising tree mulberry, cuttings are planted in the ordinary way as for bush mulberry and these are trained as standards, leaving only one erect straight branch and cutting off the side branches. Saplings raised in this manner are allowed to grow for one year and then are removed and transplanted in their permanent places to be grown as tree mulberry. These saplings can be raised in closely planted nurseries and a large number of suitable plants obtained for planting out. It is found however that plants raised in this way are much liable to be attacked by white ants and borers. A second and better plan is to raise seedlings from mulberry seeds and grow them into erect straight-stemmed plants and transplant them later on to grow into tree mulberry. The tree mulberry can be grown in many odd places like the margins of fields, the back yards of houses or any vacant ground available, or can be planted in separate fields and managed as a regular plantation. For this latter purpose, the plants are put in at distances of 12 feet from each other both ways. The plantations are not raised on irrigated garden land and cultivated intensively but are planted only as a rainfed crop on dry land fields or waste land. The trees form a valuable supplemental source of leaves in the ordinary bush mulberry tracts, even though they may not be the main or only source. The trees begin to give a good supply of leaves only after five or six years of growth, when about 2,500 lbs. of leaf per acre can be obtained.

Mulberry Seedlings. Seedlings raised in a nursery can be used not only for obtaining saplings for tree mulberry but for planting as bush mulberry as well. The method of raising a seedling nursery is as follows:—The mulberry plants flower and fruit twice a year, once in Febraury—March and a second time in July—August. Ripe berries are picked from large hardy bushes, the seeds are separated out, dried in the shade, and preserved for about a month. Fresh seeds and those which have been kept for more than six months give low germination. The nursery bed is prepared in the usual way, and the seeds are

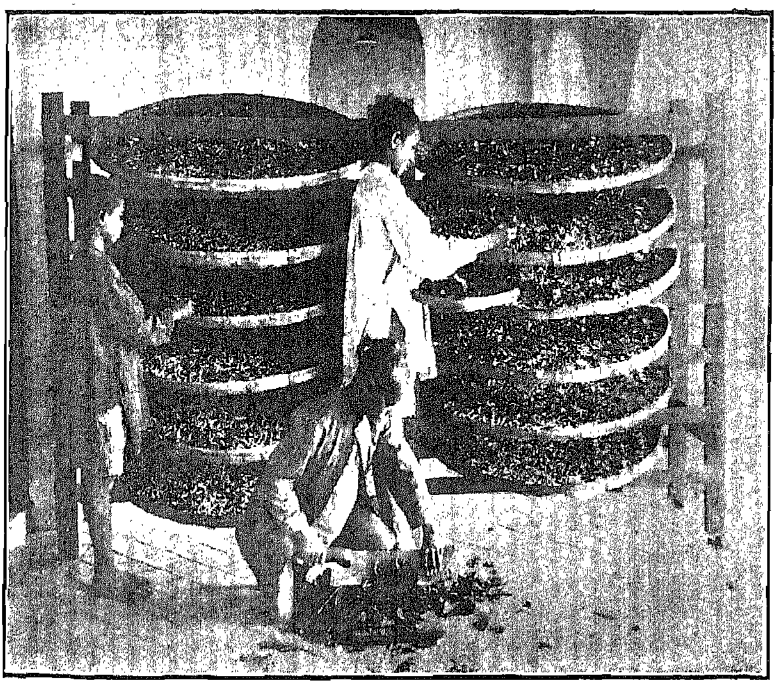
sown thinly either in rows or broadcast. Before sowing, it is necessary to treat the seeds with some camphor water, by shaking up a *tola* of camphor in a pint of a water and then soaking the seeds in it over night. This quantity of camphor water will be enough for six ounces of seed. A thin layer of fine earth and ashes is spread over the seeds after they are sown and the bed then kept regularly watered through the rose of a watering can. In nine to fourteen days, according to the season, the seeds sprout. The bed is now protected by some light shade, till the plants are about 3 inches high. The bed is now thinned out slightly and light cultivation and weeding are given. In about four months, the seedlings are two feet high and are ready to be transplanted.

Budded Mulberry.—Seedlings are raised and used for growing as bush mulberry, for growing as tree mulberry, for furnishing cuttings which are then used an planting material for bush mulberry and lastly for use as stock on which other varieties of mulberry can be budded. The "Shield" budding method has been found most successful, out of many methods tried. A system called 'high bush' has been recommended in Bengal in which good varieties are budded on to seedling stock at a height of two or three feet and the resulting plant grown as a high bush, a form somewhat midway between a tree form and a bush form. This makes the picking of leaves easier than in the tree mulberry, the leaves are cleaner and are better in quality than in bush mulberry and much heavier cocoons are obtained. These high bushes yield a full crop of leaves only from the sixth year onwards. The branches are pruned off completely once a year as in the case of bush mulberry and after every new growth the leaves are gathered by stripping.

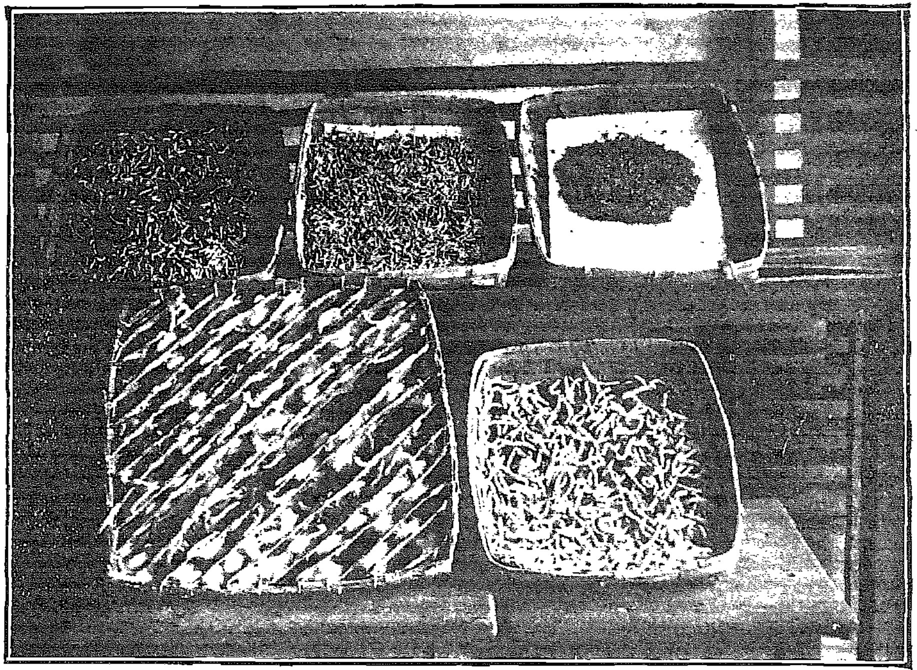
Botany and Varieties.—The mulberry plant belongs to the natural order a Urticeae, very extensive order to which the jack, the breadfruit and the numerous kinds of *Ficus* trees belong. The mulberry is classed as the genus 'morus,' but in view of the very characteristic differences between the many members of this order, it has been distinguished as a separate 'family'. The genus includes many species and varieties, some of which are large trees, others are low bushes and still others intermediate in form.

The plants are peculiar in respect of their leaves which exhibit the property called 'heterophylly' in which the leaves are of very diffierent shapes even in one and the same plant. The general shape is cordate with a pointed tip; the margins are serrate and the leaf blade may be entire, segmented variously, the two halves symmetrical or otherwise and also of various different sizes. The leaves are either dark green or light green in colour. They are single and alternate, and are attached by a long leaf stem. The surface is smooth or rough with very short minute spines. The sap from the leaves is more or less sticky.

Garden of Tree Mulberry. [Mys. Sericultural Dept.



Chopping mulberry leaves and feeding. [Mys. Sericultural Dept.



Silk-worms of various ages. (From top right to left) 1st age, 2nd age, 3rd age, 4th age and ripe 5th age worms mounted. [Mys. Sericultural Dept.

The bark of the mature stem is either light brown or ashy grey or white according to variety. The flowers are generally unisexual, but bi-sexual flowers can also be met with. The plants are both monoecious and dioecious; in some, the male flowers predominate and in others the female flowers. Plants which have only male flowers have mostly entire leaves, while in the plants with female, flowers, the leaves are mostly lobed. The leaves in the former are also more numerous. The flowers are inconspicuous and are borne on the outside of a common receptacle, which swells into the compound fruit and forms the berry. The fruit differs in shape, size and colour in the different varieties. The ovary is one-celled and one-seeded. The wood of the mulberry tree forms good timber and is used for boat building, house buildng and furniture, and most of all, for making sports articles like bats and rackets. The bast fibre of one variety (Broussonetia papyrifera) is made use for making paper. The different varieties (which are sometimes distinguished as 'species') are mainly the following:—(1) Morus alba, which is one of the best varieties and is grown both in Europe and in India and which bears fruits which are creamy white or red in colour, (2) Morus indica (sometimes put down as a variety under Morus alba) is one of the common Indian varieties and bears a red coloured fruit, (3) Morus nigra or black mulberry, largely grown in Europe, (4) Morus sinensis, grown largely in Italy, which has thin sappy leaves and is a hardy variety with long cylindrical yellowish fruits, (5) Morus philippinensis, (6) Morus leavigata, which grows into a tree and (7) Morus multicaulae or the Japanese Roso. The information regarding the varietal characters of the mulberry is meagre and confusing, but the number of varieties and types seem very large. A recent collection in the Bengal Sericultural Research Station is said to contain 110 types and this collection is by no means complete.

Pests and Diseases.—The mulberry is not subject to any serious insect pest. There are however some minor pests which attack the stem and others which attack the leaves. Among those attacking the stem the worst is probably the 'stem girdler' beetle, Sthenias griesator F. This is a medium sized longicorn beetle which rings or girdles the stem, thereby killing all the growth above the injury. The early stages of the beetle are passed in the girdled portion in which the eggs are laid. The remedial measure consists in cutting off the affected branch; the beetle should also be looked for and destroyed when found. Borers are found damaging both stems and roots. The stem borers are found mostly at the junction of the branches with the main stem and the collection of frass at the spot gives indication of the attack. The borer tunnels inside the sap-wood and causes the drying up of the branch. A simple remedy consists in squirting a little kerosine oil into the hole, which has the

effect of driving out the borer to the entrance of the hole, where it drops down dead in a few moments. The tap root is attacked by another large borer grub which often kills the plant before its presence is detected. No remedies are known but the pest is of rare occurrence.

The leaves are sometimes attacked by aphids, which not only deform and weaken the leaves but also make them unfit for the worms. The pest disappears with a good shower of rain. The only remedy is to strip off the leaves or if the attack is bad to prune the branches down.

Bushes are sometimes attacked by 'mealy bugs', the effect of which is called 'Tukra' disease in Bengal. The bugs—Phenacoccus hirsutus, Green,—cause a crumpling of the leaves, suck the sap and weaken the bushes; the damage is sometimes serious. It is stated that the 'tukra' is not caused by the bugs but that it is due to a deficiency of potash in the soil. An application of muriate of potash at the rate of 4 cwts. per acre has been found to keep down 'tukra' completely.

Another disease prevalent in Bengal which is also suspected to be a deficiency disease leads to the production of a peculiar condition in the leaves in which they become poisonous to the silkworm. Such leaves develop rusty brown patches, produced by a fungus, the nature of which is not known. Heavy rain is believed to favour the disease. The diseased leaves show an abnormal deficiency of potash and a low protein and sugar content, which is probably the effect of the potash deficiency. The disease may be amenable to soil treatment, by manuring with potash manure, though this has not been established at all.

There are no serious fungus diseases attacking bush mulberry in Mysore. Occasionally spots of white mildew—Phyllactima corylea—are seen on the leaves, generally when the leaves are young, which necessitate the plucking and rejection of such leaves. The attacks are however never serious. The tree mulberry on the other hand is subject to the attacks of some parasitic fungi, *viz.*, 'Coryneum Mori' in Kashmir and 'Nectria cinnabarina' in Europe. In the former disease, the leaves become small and few, the branches show blackened patches and later dry up. These fungi gain entrance into the trees through the wounds formed by the pruning and the breaking off of the branches, to which the trees are regularly subjected. Cracks due to frost and snow also form convenient channels of infection. Cutting out of diseased wood and the painting over of cut surfaces at pruning time with a disinfectant paint or wash are about the only ways by which the progress of the diseases can be controlled. Prunings from diseased trees should be burnt and the pruned surfaces should be cut smooth and then painted over.

Sometimes the leaves are attacked by a leaf-spot disease—Septo-gloeum mori, Lav.—in which spots appear on the young

leaves, develop into pustules like a rust disease, and cause the leaves to drop off. The affected leaves should be plucked and burnt, the bushes sprayed with Bordeaux mixture and leaves appearing thereafter alone be used for feeding to the worms.

Composition of the Leaf.—The composition of the mulberry leaf varies considerably in the different varieties. Differences in the soil composition also bring about changes which are sometimes very marked. The composition of three different varieties of leaf was found as below :—

Analysis of leaves grown in the Narayanpur Research Station (Bengal).

Composition	Leaves of		
	M. alba, moretti from Kashmir	M. indica Bengal	M. multicaulis Japan, 'Roso'
Percentage in dry matter of—			
1. Crude protein ...	28·8	28·4	18·0
2. Soluble sugar ...	13·6	12·2	11·3
3. Ash	12·0	11·8	11·3
(a) P_2O_5 ...	1·4	1·36	·65
(b) K_2O ...	3·6	3·92	2·0
(c) CaO ...	2·4	2·4	1·4
(d) SO_4 ...	·56	·54	·30
(e) MgO ...	·72	·72	·25
(f) Al_2O_3 ...	1·8	1·6	·8
(g) Fe_2O_3 ...	·06	·05	·26
(h) Si O_2 ...	2·0	1·8	2·6

The 'Roso' leaves are very large and the variety is considered one of the best varieties in Japan. It will be seen, however, that its nutritive value is much less than in the Indian varieties. In respect of leaves collected from different centres, the variation in crude protein was from 16 to 39 (expressed as percentage in dry matter of leaves); the variation in soluble sugar was from 7·6 to 26, ash from 8 to 17, lime from 0·7 to 2·7 and the iron (Fe_2O_3) from ·05 to 0·12. (Taken from papers by M. N. Ray contributed to the First All-India Sericultural Conference).

SILKWORM REARING.

The cultivation of mulberry is only for the purpose of rearing the silkworm and has indeed no other importance. It is the silkworm cocoons and the reeled silk that form the marketable products which yield the money return to the cultivator from his mulberry cultivation. The mulberry grower therefore carries on silkworm rearing as well, although a few rearers may depend upon purchased leaves. A brief account of

the methods of rearing silkworms is, therefore, given below which will apply in the main to the conditions obtaining in Mysore.

Classification and Life History of the Silkworm.—The silkworm is a caterpillar belonging to the insect order, Lepidoptera. Caterpillars,beonging to two families in this order produce silk and maylbe called silkworms. These are—(1) the Bombycidæ, which include the mulberry silkworm and (2) the Saturnidæ, which include the 'tusser' and the 'eri' silkworms. The mulberry silkworms, Bombycidæ, are divided into many groups, which differ mainly in the colour, size and silk content of their cocoons and partly in the details of their life history. The most important in the group are the B. mori, the silkworm of Europe, China, Japan, Kashmir and Western Asia, and the B. mori var. meridionalis, which is the silkworm of Mysore. The cocoons of the latter are smaller, and yield less silk; the silk is greenish yellow in colour and possesses an exceptionally fine gloss and brilliancy; the cocoons of the former are larger in size, are white in colour and yield more silk. An important difference relates however to the life history. The B. mori passes through only one generation in the year; that is to say, after they complete one life cycle, the eggs which should hatch out and start a second generation do not do so, but remain in hibernation for the rest of the year. The B. meridionalis on the other hand passes through seven or eight generations in the year; the eggs hatch in less than ten days after they are laid and begin a new generation, and these go on successively. For this reason the former go by the name of Univoltine and the latter by the name of Poly-or Multivoltine race.

The main features of the life history of the silkworm are very simple. The adult insects or moths, male and female, pair and the female then lays eggs, which are very small, cream coloured and rounded. Each female moth lays as many as 250 to 400 eggs; in a few days, about ten or twelve in the multivoltine races, the eggs hatch and tiny caterpillars, small as little bits of hair, emerge; these feed on the mulberry leaves which are given to them in a finely chopped condition and grow in size from day to day. As they continue growing they pass through four periods of 'moulting' or change of skin and in the course of about a month become fully grown. These full-grown worms which are now about 2 to 3 inches in length begin to spin cocoons and pupate. In another ten days the chrysalis or pupa inside the cocoon develops into a moth and emerges out of the cocoon after cutting a hole through it for the purpose. The moths which thus emerge are both male and female; they pair off soon after emergence and the female then lays eggs, thus completing a life cycle. For obtaining the silk, the fresh cocoons from which the moths have not emerged and which therefore are entire and

intact or unpierced, are put into boiling water in order to free the silk fibre from the gummy matter, and the silk fibres of seven, eight or more cocoons are reeled off as one silk thread over a reel. Each cocoon is made up of one single fibre which measures about 450 yards. The length may vary from 250 to as much as 800 yards according to the race of the worm. After the silk is reeled off, the naked chrysalids, which of course are now all dead, float on the boiling water and are gathered as they accumulate and thrown away. Considerable bits of silk fibre forming the rough outside of the cocoon also accumulate and are collected and preserved to be sold as silk waste. These being in outline the various stages by which silk is obtained, we shall now deal with each of them in a little more detail, drawing attention to such improvements as have been recommended.

Disease-free Eggs.—It is of the greatest importance that the eggs which form the starting point of the rearing should be free from disease. The silkworm is subject to a serious disease called 'pebrine', which is transmitted from brood to brood through the body cells of the mother moth. The eggs—also called seed, or 'layings'—from a diseased moth therefore carry the disease, which is transmitted to the worm hatching out of such eggs; these infected worms feed and grow until they are almost full-grown, when they perish in large numbers. The mortality of the worms at this stage involves a serious loss, so much so, that at one time silkworm rearing itself had to be given up on that account. Fortunately, however, the disease is at the present time capable of almost perfect control. This consists in isolating each mother moth and the layings from it, crushing up the moth after the eggs are laid, and examining her body fluid under the microscope. Infection by pebrine can easily be detected in the corpuscles and if the disease is present then the layings from that particular moth are rejected and only layings from disease-free moths are used for seed purposes. The method of isolating a mother moth and her eggs consists in confining the moth within a small ring of tin (called a cellule) resembling a napkin-ring, placed over a sheet of paper; the moth lays her eggs only within this ring, from where she is picked up for examination. Such disease-free seed is called 'cellular' seed. This work of producing disease-free seed requires special agency and special grainages or seed-production centres operate under proper control and supply disease-free seed. The pebrine disease is communicated not only through this hereditary channel but also by contact contamination. The rearing house and all articles used therein, not to mention the persons of the rearers, have therefore to be scrupulously clean and the rearing house itself disinfected every now and then. If such cellular certified seed cannot be had, then seed has to be obtained from tracts noted for good seed, from rearers of good repute, and preferably after an inspection of the rearing and of the cocoons.

From Egg to first Moult.—The eggs hatch in about ten days after they are laid; but they do not all hatch on the same day and there is an interval of a day or two between one lot and another. As worms of differing ages require attention at different periods, it becomes difficult to manage a mixed lot. In practice if most of the eggs hatch in the first day and only a small percentage is left over, then these latter are simply rejected, the hatched worms alone being transferred to the feeding tray. If, however, only a small portion is hatched on the first day, then the second day's hatching is also taken up and another tray used, there being two lots to manage in this case. This latter practice is adopted by those who can cope with the extra work involved. It is also possible to reduce this difficulty by feeding and rearing the later hatchings with greater care and in a slightly warmer room; by so doing these backward worms grow quicker and by the time of the third moult catch up with the older or first lot of worms, when both can be treated alike. Another method recommended for this purpose is to brush the eggs a day before they are due to hatch lightly over with a feather and repeat it at frequent intervals of three hours each; this process has the effect of hastening the hatching, so that a large percentage of the eggs hatch at the same time. The next day these worms are brushed into the feeding tray and the unhatched eggs are subjected to the same process, but more frequently; these hatch quickly and will be fit to transfer to the feeding tray the same day and be added to the first lot. Quite 95 per cent can be hatched out in this way and the remaining 5 per cent is small enough to be rejected.

The transferring of the newly hatched worms to the feeding tray is done by gently brushing or sweeping them with a feather on to the tray. Another simple way is to sprinkle some very finely chopped leaves of mulberry over the hatching worms; these crawl on to the leaves which can be brushed on to the trays with the tiny worms clinging to them. Once the worms have been transferred to the feeding or rearing tray either in one lot or in two lots, the next operation relates to their regular feeding and periodical cleaning. The feed at this stage consists of tender leaves, almost leaf shoots, chopped up very fine, the feeding is frequent, so that the chopped leaf is always fresh and does not dry. Some seven or eight times in 24 hours may be the number of feedings. A close and constant watch is kept, so that no feed is missed at the proper time. In two days the worms will require the first cleaning, and will have grown sufficiently as not to be damaged in the process. Cleaning consists in separating the worms from the litter or refuse made up of the excreta of the worms and the uneaten parts of the leaf. The best method of cleaning is the use of paddy husk and a net with small mesh; the paddy husk, somewhat coarsely broken up, is sprinkled as a thin layer over the worms, the net is then spread over it, and the feed sprinkled on the net. Two feedings

are given in this way over the net. The worms have now all crawled up and through the net, on top of which and quite clear of their old bed they now lie. The net with all the worms on it is now lifted up and placed on a new tray. Two such cleanings will be necessary during the first age or period, at the end of which the worms go into the first moult. At the later cleanings, the nets used are of a larger mesh suited to the increasing size of the worms. At the end of the first age the worms have developed in length and thickness, and may weigh about ten to fifteen times their weight on hatching. The first age takes about five days from hatching, and the moulting period itself may last two days or two days and a half. During the moult the worms are quite inactive and do not feed. At the end of this moult the worms have shed their first skin and the second age may be said to begin.

From the Second Moult to 'Ripening'.—In this second period also they are treated in the same way, the feed still consists of tender leaves chopped somewhat coarser, the feeding is regular and equally frequent. Three cleanings are given and the spacing is also increased by additional trays. This age lasts three days, after which the second moult begins. This is, however, very short and lasts about a day. After this moult the third age begins and this lasts about five days. Leaves somewhat more mature and chopped a little larger are now fed at about the same intervals, and four cleanings are also given. At the end of this age the worms will weigh about 300 to 400 times the original weight, with growth of size in proportion. Additional space is provided by increasing the number of trays. The worms moult again and enter into the fourth age; fairly mature leaves cut up into halves are now fed, and the number of trays considerably increased to afford the additional space required. This age occupies about five days, after which the fourth and last moult takes place, which may last for about 36 hours. The worms are now some 1,500 to 2,000 times their original weight or five times their weight at the beginning of this age. After this final moult they enter their fifth age. This is the longest and may take eight days to complete. It is an advantage to prolong this period by one day or so, which can be done by lowering the temperature of the rearing room by about 4°. The largest quantity of leaves is consumed at this period, which may amount to 75 per cent of the leaves consumed in a whole cycle. The worms are also large proportionately and additional trays will have to be provided twice during the period. The litter has to be cleaned frequently, as a large quantity accumulates on account of the larger feed and the almost full-grown size of the worms.

The extra spacing necessary at each age is provided at the cleaning time, when the worms are distributed over the additional trays required. At each one of the ages, such distribution takes

place about three times. The approximate space usually provided may be judged from the following: If trays four feet in diameter are used, then 100 layings will require at the close of the fifth or last age about 15 to 20 trays, according to the rearing season. The number of trays at the end of each age will be 1, 2, 4, 10 and 20 respectively, for the season of the best development.

Mounting and Harvesting.—At the end of the last age, the worms are 'ripe', they somewhat shrink in length, appear more rounded, and are slightly yellowish in colour. They are now ready to 'harvest' and 'mount,' so as to enable them to build their cocoons—which is the precious product of all this time and labour—in such a manner that the cocoons will have good weight and shape and be easy of picking or removal.

For this purpose the ripe worms are removed one by one and are 'mounted' or are put into the 'chandrike' or spinning frame. The point which requires to be specially attended to is to see that every worm has the right amount of space, that no overcrowding takes place and that the walls of the 'chandrike' spiral are fairly close to each other. Much ventilation is also essential and this is provided for by keeping the 'chandrikes' out in the open though not in the direct sun. The spinning is complete in a day, but it is necessary to remove the cocoons only at the correct stage which, in the case of the Mysore worm, has been found to be the fourth or fifth day; too early removal gives stained and dirty cocoons and too late removal reduces the weight and shortens the time for emergence. After the cocoons are removed from the frame and collected they are sent away for sale without delay. Cocoons vary very much in the outturn of reeled silk which they yield. The variation may range from an outturn of one of silk to ten of cocoons to an outturn of one of silk to fifteen of cocoons, in each case by weight.

The Cross-bred Silkworm.—In Mysore a great deal of progress has been made in the rearing of what is known as 'cross-bred' worms. This type of worm is the progeny of the Univoltine Japanese race crossed with the polyvoltine Mysore race. The cocoons from the cross-bred worms are larger and firmer and give a higher outturn of silk, and both silk and cocoons are white in colour, as distinguished from the greenish yellow of the Mysore worm. Furthermore, the duration of a crop is shorter by at least five days, perhaps even a week. These are substantial advantages, but against them has to be put the serious disadvantage, *viz.*, the fact that these characters are all Mendelian 'dominants' and therefore the first cross alone gives a progeny consisting entirely of white cocoons of this type and that the progeny of the cross-bred worms between themselves do not breed true. Every effort has to be made therefore to see that only first generation crosses are bred and that none of the

cross-bred moths are used again for breeding. The Government-controlled grainages or seed supply agencies alone have therefore charge of this work and guarantee that all the precautions necessary for supplying first generation crosses alone are supplied, certified as duly examined and found disease-free. One hundred disease-free layings of the cross-bred worms yield about 60 lb. of silk as against 50 or 55 lb. from the same number of layings of the Mysore local worm.

Diseases of the silk-worm.—The silk-worm is subject to serious diseases, which cause great loss, if they are not controlled properly. These are, 1. Pebrine, to which reference has already been made, 2. Flacherie, 3. Grasserie and 4. Muscardine.

Pebrine is caused by a protozoan parasite—Nosema bombycis—which infects the body fluid of the moth and also the eggs. The disease makes itself conspicuous in the worms at the third and fourth moults, when the infected worms show irregular black spots on their body; they become inactive and gradually shrivel up and die. The most effective method of control is to prepare and use disease-free eggs in the manner already described, under 'cellular seed'. In an infected crop of worms the dead and dying worms have to be picked off and the healthy worms removed to another tray which has been disinfected; this may result in saving a fair proportion of the crop. Flacherie is a digestive trouble which proves fatal to the worms. It is caused by unsatisfactory rearing conditions, and by feeding coarse, wet or fermented leaves. The worms either die off or become so weak that they yield only thin small cocoons inside which the chrysalis may die and stain the cocoons badly. Grasserie is also a fatal disease due to faulty assimilation. Affected worms either die or spin only a flimsy cocoon. The disease is probably due to a poor quality in the leaves and generally to insanitary rearing conditions. Muscardine is a fungus attack on the worms; the mycelium of the fungus enters into and ramifies in the body of the worm, which readily succumbs and dies. The body of the dead worm becomes very hard and this feature is a characteristic sign. This is a highly infectious disease but in Mysore it is neither common nor serious. Thorough disinfection of the rearing house and appliances, strict attention to the quality and condition of the leaves that are fed, the provision of adequate space, ventilation, and suitable conditions of temperature, along with scrupulous cleanliness will all greatly mitigate both the incidence and the progress of these various diseases. As regards disinfection, the most convenient material has been found to be a 2 per cent solution of formalin; this has great penetrating effect and is also safe to use. Both room and all appliances, especially the trays used, have to be disinfected properly, while the latter should in addition be frequently put out in the sun to dry.

Other Silk.—In addition to the silk produced by the mulberry-eating silk-worm described so far, there are two other kinds of silk which deserve mention, although compared with the former these are of little importance. These silks are (1) Tusser silk and (2) Eri silk. The Tusser silk is produced by the silk-worms belonging to the family 'Antheria', among the Saturnidæ. These worms feed on the leaves of a large variety of trees and shrubs, such as, Terminalia tomentosa, Terminalia katapa, Michelia champaka, the Oak tree, 'sal,' and so on. They are found both wild and are also reared. The cocoons are much larger and have a long peduncle. The silk is reeled off from the cocoons in the same way as the mulberry silk.

The Eri silk-worm, Attacus ricini, B., belongs to a different class, *viz.*, the Attacidæ. In the case of these worms, the moths are allowed to emerge before the cocoons are taken up for spinning. There is no boiling and killing of the chrysalids involved in the process; and the cocoons used are all pierced cocoons, *i.e.*, cocoons through which the moths have cut a hole and escaped. These cocoons have therefore to be spun and not reeled. The worms of this class feed on the leaves of the castor oil plant, and are reared in the same way as the mulberry silk-worm. The silk is coarse.

Chemical Composition and Uses.—The silk fibre is the product of the silk glands within the body of the silk-worm, drawn out into a fine fibre by the spinarette situated at the mouth of the worm. The silk fibre is remarkable for its length, which may extend to even 800 or 900 yards. For fineness, strength, smoothness, and lustre, it is unparalleled. Even the finest silk yarn is made up of at least six or seven fibres reeled together. Being of animal origin, the silk fibre has a high content of protein matter, which amounts to about 53 or 55 per cent. It also contains the gum 'siricin,' a material which the worm produces and uses to agglutinate together the two fine filaments of which every silk fibre, fine as it is, is made up.

In addition to its important use as a textile fibre for the weaving of various fabrics, the silk fibre is largely used as insulating material in electrical cables. Though its use for the manufacture of various articles of wearing apparel is the largest and most important, silk cloth is finding enormous use during the present war, in the making of parachutes.

Artificial Silk.—Natural silk has been very successfully imitated by various kinds of artificially produced fibres. Though these cannot displace natural silk by any means, still the fact that fabrics can be made out of them, which resemble natural silk so closely that they cannot be ordinarily distinguished, combined with their comparative cheapness, has to some extent made artificial silk a serious competitor with natural silk. All the artificial silks made at the present time are merely cellulose products; many kinds of vegetable fibres, including even cotton,

and wood pulp are used as the raw materials. Under the names of viscose silk, Chardonnet silk, or "royan" collectively, of acetate silk and copper or cuprammonium silk, artificial silk is now produced on a stupendous scale and its manufacture is still extending in many parts of the world.

Bye-products.—The bye-products of the silk-worm rearing industry are of some importance and many of them are of considerable money value. The bye-products are 1. Silk-worm pupæ, 2. Pierced cocoons, 3. Double cocoons, 4. Reelers' waste. The silk-worm pupæ are used in Japan for the extraction of an oil, which forms very good soap-making material. Being animal matter, they have a high nitrogen content and can be used therefore also as a valuable manure. Dried and ground after extracting the oil, or merely pressed into briquettes, they should be capable of being easily transported for use as manure wherever required. The pierced cocoons, double cocoons and reeling wastes have much money value and are bought up for conversion into 'spun' silk. In this respect, by far the most important is reelers' waste.

Production and trade.—As far as South India is concerned, the silk-worm rearing areas are situated in Mysore and Kollegal. The area under mulberry cultivation in Mysore has been varying very much owing to the violent fluctuations in the price of silk but on the whole there has been a material increase in acreage. In the year 1940-41 the area was 38,480 acres, as against 25,132 acres in 1936-37.

In the Kollegal tract the area in 1938-39 was 5,735 acres as against 15,387 acres in the year 1923-24.

The total production of silk in India has been estimated at 1,500,000 lb. which is nearly all used up in the country itself. There is an enormous import of silk of all kinds, both as yarn and as woven goods. The annual import of raw silk or yarn is about 2,000,000 lb. valued at Rs. 6,200,000. The export of silk is negligible, being only about 20,000 lb. valued at about Rs. 100,000.

II. PARA RUBBER—(Hevea brasiliensis).

The cultivation of the Para-rubber yielding tree—Hevea brasiliensis—in India is a remarkable instance of the rapidity with which a crop entirely new to the country has been taken up for cultivation over large areas and has become established as an important and flourishing planting enterprise within a surprisingly brief period. The introduction of the Para-rubber plant into India dates back barely sixty years and the actual cultivation on any large scale can be said to be only some forty years old. And yet it has expanded so rapidly that the Indian production of rubber at the present time is estimated at

over 16,000 tons per year. It is also noteworthy that the cultivation is largely confined to South India, the southernmost corner of the Peninsula *viz.* Travancore, forming indeed the most important area.

Sources of Rubber.—Rubber is obtained from the latex or milky fluid which is found in the tissues of various plants and which exudes when the plants are cut or bruised. There are many different trees other than the Hevea brasiliensis from which rubber can be and indeed is obtained, although the latter forms the most important source and as a cultivated tree the main source of all the rubber of commerce. These rubber yielding plants comprise large trees, giant creepers, vines and low growing shrubs, and the latex can be derived from many parts of the plant, such as, the bark, roots, leaves, stems and even tubers and fruits. Among rubber yielding plants other than the Hevea may be mentioned the following:—

1. Manihot glaziovii, or the "Ceara-rubber" tree.
2. Castalloa elastica, yielding "Castalloa rubber".
3. Ficus elastica, or "Assam rubber".
4. Mimusops globosa, or "Balata rubber".
5. Fentuma elastica.
6. Bleekrodea tonkinensis. All these six are large trees.
7. Landolphia (Kirkii, Watsonii and other species), which are giant creepers.
8. Cryptostegia grandiflora, a bushy creeper, called the 'Madagascar Rubber' Plant.
9. Parthenium argentatum, the shrub which yields 'guayale rubber'.
10. The tubers of Raphionacme utilis.
11. The fruits of the Chinese plant, Enconia illinoides.

Many shrubs and annual weeds of the Euphorbiaceous order yield latex capable of conversion into rubber. In Soviet Russia many shrubs among the Compositeæ order, besides the Parthenium, have been found to contain rubber-yielding latex. The Russian dandelion "Kok-Saghyz" Taraxicum Spp. is now being cultivated extensively in that country for the sake of the rubber which is contained in their roots. So far, however, the Hevea rubber tree has been found the most suitable as an economic source of rubber, lending itself to large scale cultivation, and yielding rubber of good quality, from about five years of age up to forty years or more. It has therefore been cultivated as *the* rubber tree *par excellence* throughout the rubber-growing parts of the globe.

Distribution.—The home of the Para-rubber tree is considered to be the primeval forests in Brazil lying on both sides of the lower reaches of the River Amazon and especially the province of Para therein, from which the plant derives its name. In this equatorial belt the tree grows wild and attains great

height and girth, forming part of the giant vegetation. Its introduction to the East, and especially to Ceylon, is a story of perilous adventure, but once established here its cultivation has spread far and wide into countries not only within the tropics but also in the sub-tropical zone. In many of these countries of its new home the tree has been found to make as good growth as, if not better than, in its original home in Brazil. The Para-rubber tree is now cultivated extensively in South India, Ceylon, Burma, Malaya and the Straits Settlements, Borneo, Java, Sumatra and many South Sea Islands, West Africa, Central America, Venezuela, Equador, Columbia and the West Indies. In India itself it is confined (with the exception of small areas in North Eastern Assam) to the southern extremity of the Peninsula. Travancore, Cochin, Coimbatore, the Nilgiris, Wynaad, Coorg and Mysore are the most important areas of cultivation.

Altitude, climate.—In its original home the Para-rubber tree grows practically at sea level and at low elevations, in contrast with its cultivation in India, where it occupies mostly the hilly country lying on the slopes of the Western and to some extent of the Eastern Ghauts, and therefore situated at a comparatively high elevation. Very large areas are thus grown at altitudes ranging from 1,000 to 2,500 feet above sea-level, about 3,000 feet being about the maximum. The tree can at the same time flourish in low flat situations, near river banks which periodically overflow, and near creeks along sea coasts. In regard to altitude therefore the tree is very adaptable.

Rainfall and other climatic conditions are of greater importance in the cultivation of the tree. The tracts where the tree flourishes are all areas of heavy rainfall, and in the best of them the rainfall is also well-distributed throughout the year, so that there is hardly a single month without any rain. An annual rainfall of about 60 inches may be said to the minimum, while a heavier rainfall of even 100 inches is not found harmful. Some of the rubber tracts of Ceylon indeed belong to the latter category. It would however appear that, even if the rainfall is very much less, if it is well distributed with rain every month of the year, the tree can flourish; the rubber tracts of West Africa, where the rainfall is only about 40 inches in the year seem to be an illustration.

The tree also adapts itself to considerable variations in temperature. In its native home the temperatures are said to be very uniform. In Ceylon and South India however there is a large variation between the summer and cold weather temperatures, which may range from about 95° as a maximum down to 60° as a minimum. A high annual rainfall of 60 to 70 inches, with as short a rainless period as possible, a high humidity and a mean temperature varying between 85° and 65° may be said to be the climatic requirements of the crop.

Soil.—The rubber tree is grown on a variety of soils. In some countries the soils are fine alluvial deposits which are added to every year by the inundations of the creeks and rivers. Others are swampy soils with water very near to the surface of the soil with a high organic matter content almost resembling peaty soils. Others again are rich forest soils in which the nitrogen content is markedly high. The bulk of the soils of South Indian plantations are reddish lateritic loams or clayey loams. They are on the whole poor except where they are covered by heavy forest growth and protected from erosion. In the latter situations they are fairly rich in nitrogen, but are poor in mineral constituents. All these soils require considerable manuring, especially in regard to the addition of organic matter, in the shape of green manuring and cover crop vegetation. The high content of iron and alumina is also a characteristic of most of the rubber soils in South India. In texture they are mostly clayey loams. All soils are generally deep and well drained, but low situations with water very near to the surface are also planted with rubber, which is apparently quite in contrast with tea or coffee.

Propagation.—The Para-rubber tree is propagated both by seed and also vegetatively by means of budding.

(*a*) *Propagation by seed.*—The Para-rubber tree flowers and fruits profusely and produces a large quantity of seed. The fruit of the Hevea tree is a three-lobed capsule about an inch in circumference and contains three small rounded seeds which have a smooth hard coat. The seeds are peculiar in that they do not retain their vitality for any length of time and have to be sown fresh for satisfactory germination, as soon as possible after they are gathered. Seed intended for sowing should preferably be gathered from selected trees which habitually yield a large quantity of latex instead of from the mixed crop in a plantation, although of course there may be no certainty that the progeny will all be true to the parent tree in performance. Seeds are obtainable in large quantities during the months of September and October.

The nursery is prepared in the usual way and the seeds are sown therein at distances of nine inches from each other in rows one foot apart. The nursery is protected against sun and rain by a temporary shelter about eight or ten feet high, made of light thatch lattice-fashion. The seeds sprout in about ten to twelve days. With due attention to regular watering and weeding the plants make very quick growth. In six months the plants attain a height of 3 to 4 feet and will be ready for transplanting.

As an alternative, seedlings may be raised in seedling baskets, bamboo hollows or in narrow cylindrical earthenware pots, one seed or two being sown in each and the weaker

of the two seedlings being removed when two seeds are sown. Instead of raising seedlings in a nursery and transplanting out later, it is also usual to sow the seeds in their permanent place in the estate itself; two or more seeds are planted in each hole and all but the sturdiest seedlings are removed later on from each hole.

(*b*) *Propagation by budding.*—Almost a revolution in rubber planting has come about as the result of propagating the plants by budding. One of the remarkable features of the rubber tree is the great difference in the out-turn of rubber between one tree and another. The difference may be so great that one tree may yield ten times or more of rubber than another under similar conditions. Trees of outstanding performance are selected after a study of their performance records of some years and are made use of as mother trees for furnishing "clones", *i.e.* budwood for providing buds to be budded on to seedling rubber plants. The latter form the stock and the growth from the clonal bud forms the scion of the new budded plant. It is claimed that a definite correlation exists between the size of the vascular tubes in the young plant and its rubber yielding capacity later as a tree. This finding if really well established makes it possible to select clonal plants at a young stage, without having to wait for seven or eight years to judge their performance. Plantations of budded rubber plants yield two or three times as much rubber as plantations of seedling rubber trees. The system of budding and planting of budded plants which originated about the year 1915 has now become very general and is rapidly displacing the older method. The budwood was derived in the first instance from certain high yielding parent trees in Sumatra and Java, and some of these 'clones' have become famous and are largely in demand.

The following are some of the more famous 'clones':— 1. AVROS, from Sumatra, 2. Bodjong Datar, (B.D.) from Java, 3. The Tjr. (Tjirandji), from Java, 4. Djs. (Djasinga), also from Java, 5. P. B. (Prang Besar), 6. Sabrang, 7. Rubana, 8. Glenshiel and several others from Malaya. About 10 per cent of the total area under rubber in India is now under budded plants.

The technique of the budding is not different from ordinary shield budding of fruit and other trees. Budding is carried out either in the nursery where the seedlings are raised, on the seedlings in the nursery itself or on the seedlings planted out in their permanent places in the estate. Nursery seedlings intended for budding are grown spaced about 18 inches each way. Seedlings are from one to one and a half years old when they are used for budding. Budding is done when the plants are growing vigorously and not when they are wintering. Likewise budding is more successful when done in fair weather rather than during the rains.

Planting out.—The plants, either seedlings or budded, are planted out in the estate in pits about two or three feet deep and about two and a half or three feet square, filled with good jungle soil. The distance between the pits varies a great deal according to the policy adopted. Thus, if many trees are to be removed after a few years of tapping, leaving the remainder as permanent ones, then the planting is close, *i.e.*, 10′ by 10′, or 12′ or 12′, or 15′ by 15′; if on the other hand the estate is to be planted with trees all of which are intended to be permanent, then a distance of 20′ by 20′ is adopted. Both in this case and ultimately in the former case the estate carries a population of a little over 100 trees per acre. The planting of a nurse crop or a cover crop for green manuring, either prior to or immediately after the planting of the rubber plants, is necessary and is usually done. The crops selected for this purpose are mainly Bogamedalloa (Tephrosia candida), Cow-peas, Centrocema pubescens, and Pueraria phaseoloides. These are sown between the rows and in the same and succeeding years are cut down and otherwise worked into the soil. Shade is seldom provided; the rubber plants grow so quick and tall that the need for shade trees is not felt.

The rubber plantation is therefore usually one purely of rubber except where other economic crops like tea or cocoa or coffee are interplanted, and the plantation worked as a mixed plantation. If the plants are more than six feet when they are transplanted they may be topped at a little over six feet so that when they are of tappable age a well-developed trunk with a large surface may be secured within a height of six feet.

After the plants are well established and during every year the plantation is given the usual cultural operations, *viz.*, weeding, digging and manuring and the cutting down of cover crops and mixing them with the soil. All possible care is also taken to prevent damage to the young rubber trees, especially against injury to the bark. Tho plants make very rapid growth both in height and girth, and this rapidity of growth is indeed remarkable, especially under favourable conditions. Under favourable conditions, good growth may be reckoned as about 5 to 6 feet of height per year during the first four years; thirty-year old trees may attain a height of some 80 feet. Likewise an increase in girth of four to five inches per year may be expected and a thirty-year old tree has been found to have a girth of 12 feet in circumference. If rainfall conditions are not so favourable, then growth may be much less in comparison, nine years old trees being 24 to 46 feet. The trees do not branch low and the stems are clean and unbranched for a great height. The crowns are carried high and have a spread of 30 to 40 feet in diameter in well grown trees exceeding 20 years.

Rubber responds well to manuring with nitrogenous manures which stimulate both healthy growth and an increased yield of

Plantation of Para-Rubber, with a heavy growth of a Cover crop. (From the "Tropical Agriculturist."
[Ceylon Agricultural Department.

Plantation of Para Rubber on contour platforms, with a heavy growth of a cover crop.

[From the "Tropical Agriculturist," Ceylon Agricultural Department.

rubber. The response to phosphoric acid and potash has not been found satisfactory. Green manuring with the various cover crops mentioned is a cheap form of nitrogenous manuring. But for really good results and for stimulating production, especially in old plantations, the application of sulphate of ammonia or sodium nitrate, the former at the rate of four cwts., and the latter at the rate of five cwts., per acre is recommended.

Tapping for rubber.—The rubber tree has to grow sufficiently large in girth before it can have a good tappable area of bark and yield a remunerative supply of latex. Moreover the latex from young trees yields rubber which is low in out-turn and quality. For these reasons trees are not tapped before they are seven years old. It is usual to tap even at the age of four years, but this is done in estates which are planted very close and which are to be gradually thinned out, and also when prices of rubber are high or other economic considerations justify it. The tappable area is generally confined to a height of six feet from the ground, that is, within the reach of the tapping coolies. It is however possible to tap the stem to a much higher level. Heights up to even 20 feet are sometimes tapped, though very rarely. The six feet height is the most common, principally because it is the most convenient one in practice and also because the latex from higher parts of the stem is of inferior quality. The tapping operation is confined to the morning hours of the day, as the flow is more free during this part of the day.

Tapping methods.—The tissue of the bark which bears the largest number of the latex-containing tubes or cells lies deep and very close to the cambium and runs up and down the stem. The cut or incision into the bark has therefore to be across this length, more or less horizontally and close enough to the cambium to tap the largest number of these vessels and at the same sufficiently clear of the cambium as not to injure it. The cut is made by means of special tapping knives, which are adjusted to cut the proper depth. In order to facilitate the flow of the latex into the cup which is to receive it without its coagulating during the flow the cut is made not quite horizontal but in a sloping or oblique direction either straight or in a slight curve or spiral course, either full or half, along which the latex flows into the cup. The different methods of tapping are distinguished as follows :—1. The "herring-bone" system, in which oblique cuts are made which alternate with each other and open on either side of the vertical cut or line. These oblique cuts may be (*a*) on both sides of the line or (*b*) on only one side. 2. The spiral system in which two are distinguished, *viz.*, (*a*) the full spiral and (*b*) the half spiral, which are self-explanatory. The half spiral itself may have the spiral cuts on only side of the vertical line or on both sides. 3. the V cut system, in which two slanting incisions are made like the two arms of a V which nearly meet at the lower end, where the latex receiving cup

is fitted. The half-spiral method is at present the one very generally adopted. Each day's tapping consists in taking a thin shaving or paring off the top of the cut surface of the bark; the latex quickly wells up, following almost the blade as it is moved along, and flows slowly down into the cup. Before beginning the tapping, the coagulated remains of the previous day's latex are scraped or peeled off, these being collected as 'scrap'. The layer pared off at each tapping is thin as paper and a month's tapping will remove only about one inch of the bark.

Tapping Intervals.—Tapping is done at intervals which vary in different estates and according to circumstances, and a period of rest, short or long, alternates with a period of tapping. These periods may consist of one or more days, a week or a month. Thus tapping may be done for a day or a few days, a week or a month and then be followed by a day, or days, a week or a month, respectively, of rest. Tapping is suspended when the trees are passing through a leaf fall or wintering and is resumed when the vegetative growth begins and the sap begins to flow. Likewise during rainy weather also tapping is stopped. Making allowance for these stoppages there may be from 130 to 160 days of tapping in the year.

All tapping implies a lessened vitality in the tree, a loss of bark tissue and liability to disease. The intensity of tapping should therefore be such as not to endanger the life of the tree. A very light tapping method is to divide the bark area into three vertical divisions or panels and tap one division each year successively; each panel gets a rest of two years before it is tapped again. A very intensive tapping, amounting to "slaughter tapping" will be to tap daily or on alternate days, on the full spiral system, and if on the half spiral then tapping both panels. Usually the bark requires a rest of two to three years for satisfactory regeneration.

Collection of the Latex.—The latex is collected in small collecting cups placed at the lower end of the cut into which it flows through a small spout, which is fixed into the bark just above the receiving cup. These cups are made of enamelware, tin or aluminium, or are sometimes only halves of cocoanut shells. They are of sufficient size to hold the day's flow and are fixed suitably to the stem. As the cups fill the contents are transferred to larger collecting vessels which are then taken to the factory. Sometimes a few drops of formalin are added to the latex in the cup to keep it from coagulating in the cup. A certain amount of latex coagulates and dries up in and about the cut and this is scraped together and brought in later on as scrap rubber.

The latex is not always of the same quality and varies somewhat considerably in the out-turn of rubber. The variation may be due to the individual peculiarity of the tree, its age, and the time or season of tapping and so on. The variation may be so

great that the out-turn of rubber from a gallon of latex may range from 2½ to 4 lb.

The Preparation of Rubber from the latex.—The latex contains the rubber in the shape of fine globules intimately mixed like an emulsion with the water and the liquid and solid constituents of the latex, very much like the fat globules in milk. The other solid constituents comprise proteins, sugars and salts. In order to prepare rubber the globules or particles of rubber in the latex have to be separated from the water and the solid constituents. The separation can be effected by simple coagulation or by centrifugal action. In ordinary estate practice it is the former method, *viz.*, coagulation, which is adopted. The fresh latex when kept for some time coagulates into a tough homogenous white mass and this coagulated layer floats on the top of the thin serum-like fluid, from which the coagulum has separated. This coagulum contains all the rubber, together with a part of the water, the proteins, and impurities. The coagulation can however be hastened and to some extent controlled, by the addition of a little acid to the fresh latex which is slightly alkaline with a pH. value of 6 to 7·2. The acid used is generally acetic acid, and a few drops of this are quite enough for a gallon of latex. In practice, a simple litmus paper test is advisable, so that the latex becomes only just acid or practically neutral. Many other chemicals and especially formic acid, can be used for coagulation, but in practice, acetic acid is found most convenient.

The preparation of rubber on the estate is carried out in three stages, *viz.*, (1) coagulation, (2) pressing, (3) drying and smoking.

Coagulation.—The fresh latex is diluted with water (up to its own volume as a maximum) and strained through a hair sieve to remove bits of bark, fibre, particles of earth, etc. It is then poured into shallow trays, either circular or rectangular in shape. The former may be about 12 inches in diameter and 1½ inches deep, while the latter may be 9 inches by 18 inches and 1½ inches in depth. The latex is acidified or left to itself. The coagulation sets in at once and the layer of rubber may be ready to lift out of the trays within 24 hours.

Pressing.—The next process is to wash the rubber in water, free of impurities as far as possible. The washed rubber (called "biscuit" or 'sheet' according as it set in a circular tray or a rectangular tray) is now passed through a pair of rollers somewhat like a mangle; in this process much of the water together with some of the dissolved impurities held in the coagulum is squeezed out. The surface of the rollers is either smooth or is grooved zig-zag, straight or diamond pattern, and in the latter case the sheets have this pattern printed on their surface, as they come out of the press.

3. *Smoking and Drying.*—The 'sheets' and 'biscuits' are then dried in a drying room over smoke from a wood fire. Although the main object at this stage is only to dry the rubber thoroughly, the smoking is resorted to in order to prevent mouldiness and bacterial deterioration later on. The creosote in the smoke exerts this preventive action on the rubber. After the rubber is smoked it is dried in a free draught of air. The resulting product is the yellowish brown plantation rubber, either "biscuit" or "sheet," in which condition it is shipped to the manufacturers.

Yield of Rubber.—Normally rubber trees are tapped when they are seven years old. The yield increases steadily until at the age of about 15 years the trees may be said to be at their best. As already mentioned trees may be tapped even from the age of four years, for various reasons such as for thinning, or during high prices and so forth. A normal yield from seedling-raised trees may amount to about 300 lb. of rubber per acre in South India. The yield on estates where the trees are budded from selected clones is generally at least twice this quantity, often times very much more. From 700 to 800 lb. per acre may be considered a fair yield for such budded plantations. From other countries like Ceylon, Java, Malaya, and Sumatra, yields of even 1,500 lb. of rubber per acre of budded trees are reported. The variation in yield from tree to tree is very great in seedling rubber; it may range from 2 lb. to 20 lb. and specially good clones yield even 30 lb. This explains the low yield from promiscuously planted seedling plantations, and shows at the same time the possibilities of plantations of budded trees budded from selected clones.

Botany and Varieties.—The Para rubber tree (Hevea brasiliensis) belongs to the natural order Euphorbiaceae, an order which comprises many tropical trees, shrubs and herbs most of which contain a milky juice which exudes from the cut tissues. The genus, Hevea itself, embraces several species all of which yield rubber, though the 'brasiliensis' is the main source of all the para rubber of commerce. The tree has a long tap root and massive side roots and grows to a great height. The stem is smooth and straight and is generally unbranched up to a good height above which it bears a much branched leafy canopy. The tree is diciduous but the leafless period is very short, lasting about a week or ten days and rarely two or three weeks. The leaves are trifid and borne at the end of a very long petiole, are bright green, long and lanceolate. The tree is monoeceous; both male and female flowers are borne in fact upon the same inflorescence, which is a compound raceme. The female flowers are borne mostly at the terminal ends and the male flowers lower down. Both male and female flowers are bell-shaped and have a corolla of five yellow petals, and the female flowers have a green

button-like expansion or receptacle which is surmounted by a three-celled ovary, on top of which are three whitish lobes of stigmas. The male flower has all the filaments united into one, with two whorls of five yellowish anthers each. The fruit is a capsule, containing three seeds which have a hard shining coat, speckled brown. When the capsule is ripe it splits and sheds the seeds. The seeds are oleaginous and contain up to 35 per cent oil.

There is a very large number of strains, as may be evident from the great differences in the performance of individual trees, which forms the basis for the selection of clones. These individuals differ not merely in the yield of rubber but also in other characters of economic value such as vigor, rate of growth, bark renewal, susceptibility to disease and wind damage and so on. Some of the well-known clones now used for propagation have already been mentioned. It should be possible and indeed very desirable that performance studies should be made in South Indian plantations and suitable mother trees selected for clonal propagation.

Pests and Diseases.—The Para rubber tree is not subject to any serious insect pests like other crops. Scale insects on the twigs and leaves, a borer (Xyleborus perforans) boring into the bark and interfering with the flow of latex, and a root and stem borer (Batocera rubus) are met with but none are of any serious importance. The bark borers are prevented from doing much damage, as they become fixed in the latex and die.

Diseases.—The tree is, however, subject to many fungus diseases, some of which are serious.

(i) The most important among these is the "Pink disease"—Corticum salmonicolour. This disease appears on the bark of the tree, on which it forms a rose coloured or whitish crust. Usually it is the under side of the horizontal branches which show the disease. The bark in the attacked portion splits and peels away, leading to a virtual 'ringing' of the branch and its death. Heavy rains favour the disease and it is the forks of the trees which form the starting points. Some mitigation of the damage can be obtained by (1) reducing the shade in the plantation and (2) coating the forks of the young trees with Bordeaux mixture. Trees which have died or badly damaged should be cut down and burnt.

(ii) Another serious disease is "Black thread"—Phytophthora Meadii, Macræ, with which is associated an "abnormal leaf fall." The disease appears at and about the cuts made for tapping; the bark begins to bulge at the cut and decay of bark and wood then sets in. The whole area about the cut becomes covered with a sooty black coat. The latex suffers both in quantity and in quality. A great weakening of the tree results on account of the abnormal leaf shedding. The progress of the disease may be controlled by (1) giving the tree rest by suspending the tapping and (2) at the same time, applying disinfectants

to the surface at the cut. The surface may be covered with Izal or carbolineum, or smeared over with a mixture of tar and tallow.

(iii) Another disease due to a similar fungus, *viz.*, Phytophthora Faberii, is the formation of 'Canker' about these cut surfaces, which if not attended to will eat into the wood and cause the death of the tree. The progress of the disease may be arrested by cutting out all diseased tissue, and burning it. The affected surface should also be smeared over with tar.

(iv) " Die back " is a disease which attacks nursery seedlings and also young trees in the plantation. The branches begin to wilt, dry and die from the tip backwards, leading to the death of the branch and later of the seedling itself. The fungus causing the disease is present in the soil and gains entry into the plant through wounds or bruises. Keeping the surface of the soil clean by the removal and burning of all rubbish, cutting out the diseased branches promptly and covering the surface with tar will keep the disease in check.

(v) Root diseases caused by species of Fomes, and by Poria *hypobrunnea, bring about the death of rubber trees and is a* serious trouble especially in newly replanted rubber areas. Old rubber roots and other debris has to be cut out and burnt, in order to save the new trees. As this work will be quite out of the question if it has to be carried out over the whole estate it has been suggested that certain cover crops may be sown and used as indicators. Crotolaria anagyroides and Tephrosia Vogelii are both susceptible and the patch where they begin to die may be taken as centres of infection and these spots promptly treated by removing all old roots and plant residues and by burning them.

(vi) A disease which causes serious loss is what is called, " Brown bast ", which affects the cortical tissues. The first symptom is a cessation of the flow of latex from isolated patches of the bark; a brown discolouration then occurs and this is followed by the formation of bulges or nodules on the tapping surfaces, which makes it uneven and incapable of being tapped. It is not known whether the disease is fungoid, bacterial or only physiological. A heavy flow of latex, either as an individual peculiarity of the tree or as the result of excessive tapping, is generally regarded as tending to produce the disease. Remedies which are adopted with more or less success are the stoppage of tapping, light tapping, cutting out or scraping off the affected parts and applying disinfectants like tar or other materials. One theory regards the disease as being spread from the affected portions and on this is based the remedy of isolating such patches by deep incisions going right down to the cambium and severing the lactiferous tubes completely.

(vii) Abnormal leaf shedding caused by " Oidium " is also a common trouble, both on plants in the nursery and large trees

in the plantations. Dusting with sulphur keeps down the disease. On large grown-up trees the method is not practicable ordinarily, but the feasibility of using aeroplanes to dust the sulphur from has been tried experimentally.

(viii) Another disease of the bark is the "Mouldy rot," due to the fungus *Sphaeronema fimbriatum*. Small black spots appear above the tapping cut on the renewing bark, which coalesce and spread, leading to the decay and death of the bark; the surface becomes black and the dried bark falls away exposing the wood and forming fresh wounds. If tapping is continued the whole bark of the infected panel becomes damaged and no bark renewal takes place for many years. Spores adhere to the persons and clothing of the coolies and serve to spread the disease. Tapping should be stopped on infected trees, all scrap therefrom should be burnt and the surface painted with a disinfectant like Brunolinum, 20 per cent solution in water. All collecting cups, tapping knives and such materials should be likewise disinfected by immersion in the disinfectant.

Chemical Composition and Uses.—The latex of the Para-rubber tree is composed of water, globules of rubber, proteins, sugar, resins and mineral salts and is slightly alkaline in reaction when freshly drawn. It has a pH value ranging from 6 to 7·2. It has a specific gravity ranging between 0·9 and 1·04. It turns neutral and even slightly acid within a short but varying period and in this condition rapidly coagulates. The latex as it comes from the estate contains also impurities like bits of bark, sand, etc., which are all of course removed by filtration before the latex is set to coagulate. The quality of the rubber prepared from the latex will depend upon the extent to which the proteins, sugars and resins have been removed. The more of these are present the more is the risk of the rubber deteriorating by bacterial action and becoming soft or 'tacky.'

Para rubber latex is not of the same uniform quality, but varies slightly in composition according as the tapping season is wet or dry, according to the age of the tree and the part of the tree from which it is derived. Broadly, the composition of the latex is as follows:—Water 55, Rubber 32 to 41, Proteins 2·2, Resin 2·0, Sugar 0·36, Ash 0·4 (Bamber).

The latex of other rubber yielding trees differs markedly in the rapidity of coagulation; thus, Ceara and Landolphia coagulate as they are drawn and have to be peeled and scraped off from the bark. Ficus elastica (Assam rubber) latex coagulates with difficulty.

Latex is sometimes handled and transported as such in bulk, for use in manufacture or other purposes. In order to maintain it in the liquid condition it is rendered definitely alkaline by the addition of ammonia.

Ordinary plantation rubber has a composition roughly as follows:—Moisture 0.3, Rubber 93·46, Protein 3·5, Resins 2·36, and Ash 0·38 (Bamber).

Plantation rubber has to be cleaned of its impurities and 'sulphured' or 'vulcanised' before it can be used for the manufacture of rubber goods. The purified rubber when heated with sulphur at temperatures ranging from 125°F to 300°F takes up the sulphur partly in chemical combination and partly as free sulphur; the quantity of sulphur added is about 4 to 5 per cent for ordinary vulcanisation and as much as 20 to 40 per cent for materials like ebonite.

The chief use of rubber continues to be for the manufacture of pneumatic tyres and tubes for automobiles, lorries, "tanks" agricultural tractors and wheeled implements. For water-proofing garments and other articles, for electrical insulation, and for the numerous rubber goods like tennis balls, shoes, mats, gloves, bags, hose pipes, tubes, elastic bands and belts, dolls and toys and so on, rubber is being used as an indispensable material, and further new uses are being constantly found.

Production and trade.—India is one of the chief rubber producing countries of the world. Rubber planting has passed through many vicissitudes and at the present time a great extension in area and increased production from the existing plantations are both taking place. The annual production in India is estimated at 16,000 tons and the total planted area including areas planted up to the end of 1941 is 136,614 acres. Out of this area, Travancore alone grows 104,474 acres or about 80 per cent, Cochin grows 12,463 acres, Coorg 3,079 acres, Mysore 639 acres and the British Indian Districts the remaining 15,958 acres.

Until recently a large portion of the Indian production was being exported but with the starting of the local manufacture of pneumatic tyres, tubes and other goods the local production is nearly all absorbed in the country itself.

Substitutes for Para rubber.—The preparation of substitutes for Para rubber, especially of the artificial or synthetic types has occupied attention for a long time and much scientific work has been carried out successfully. Manufacturing methods on a large industrial scale are said to have reached a high degree of perfection under the pressing necessity of the present world-war. It is surmised that the end of the war will see synthetic rubber coming into the market as a formidable competitor with natural rubber. Many different types have been successfully prepared under the names of Buna, Thiokol, Koroseal, Neoprene, Resistoflex, S. K. B., and so on, the first of these, *viz.*, Buna, which is a German product is considered the best. It is now manufactured on a very large scale in the U.S.A. under the name of Butadiene rubber.

Other substitutes comprise the natural product itself, *viz.*, rubber, derived however from many kinds of trees and shrubs, other than the Para rubber tree. The latex from most of these suffer from some drawback or other as a source of rubber. They have a low content of rubber, or and a high content of impurities

like resins and gums, or present difficulties in extraction. Under the stress of the war, however, technical methods are being successfully worked out in order to overcome these difficulties and many plants are now being exploited for rubber. Among these, the Russian Dandelion,—Kok-Saghyz—is the most noteworthy. It is reported that the plants contain in their roots some 6 to 8 per cent of rubber, (calculated on the dry weight of the roots) that both cultivation and extraction are easy, and that the Soviet has already planned to put down two million acres under the crop. The Guayale rubber of Mexico, is being largely exploited in the U. S. A., while in India itself the climbing shrub Cryptostegia grandiflora has been found promising and is now under large scale experiment.

A third class of substitutes is furnished by certain made up products or compositions, which are so treated and mixed that the resulting product resembles rubber in some respects and can indeed be used for some purposes as a substitute.

APPENDIX I.

MANURES AND FERTILISERS.

Table showing the percentages of the principal plant food ingredients contained in different manures and fertilisers.

Name of Manure	Nitrogen N	Phosphoric acid P_2O_5	Potash K_2O	Lime CaO
Farm Yard manure ...	0·3—1·1	0·3—0·54	0·4—1·1	0·65 to 1·3
Horse manure ...	0·6—1·5	...	...	...
Sheep manure ...	0·8—1·6	...	...	...
Poultry yard manure ...	1·2—1·5	1·5—2·0	...	...
Guano	0·3—2·0	5—35	0·2—3·5	3—18
Blood (dried) ...	11·5	...	...	...
Castor Oilcake ...	5·5—8·7	2·6	...	...
Groundnut ,, ...	6·5—8·8	1·4	...	...
Honge (Pongamia glabra) Oilcake.	3·5—4	·8	...	...
Neem (Melia azhadirachta) ,,	4·4—5·9	1·3	...	...
Safflower ,,	3·9—8·4	1·1	...	...
Bonemeal, Raw ...	3·6	18·6—23	...	31
,, Steamed ...	1·5	30·9	...	41
Bonechar ...	0—0·5	26	...	37
Fish manure ...	4—6	1·7—7·5	...	...
Super Phosphate ...	...	14—21	...	...
,, Concentrated ...	...	35—45	...	...
Basic Slag ...	...	16—20	...	45
Trichy Phosphates ...	...	25·5	...	44
Ammonium Sulphate ...	20·5	...	...	...
,, Chloride ...	24·5	...	...	...
Calcium Cyanamide ...	18—21	...	...	...
Urea (Floranid) ...	46	..	...	...
Sodium Nitrate ...	15·5	...	...	...
Nitrochalk ...	15·5	...	...	35
Potassium Nitrate ...	13·5	...	45	...
Ammophos A ...	10·7	46	...	...
,, B ...	16·5	20	...	...
Diammondiphos ...	20	53	...	...
Leunophos ...	20	20	...	...
Phosphazote ...	7	15	...	...
Potassium Sulphate ...	...	...	48—52	...
,, Chloride or muriate.	...	...	50	...
Kainite ...	...	...	14—30	...
Leunophoska ...	10	10	13	...
Nitrophoska ...	16	16	16	...

Diagram showing the manner of mixing manures.

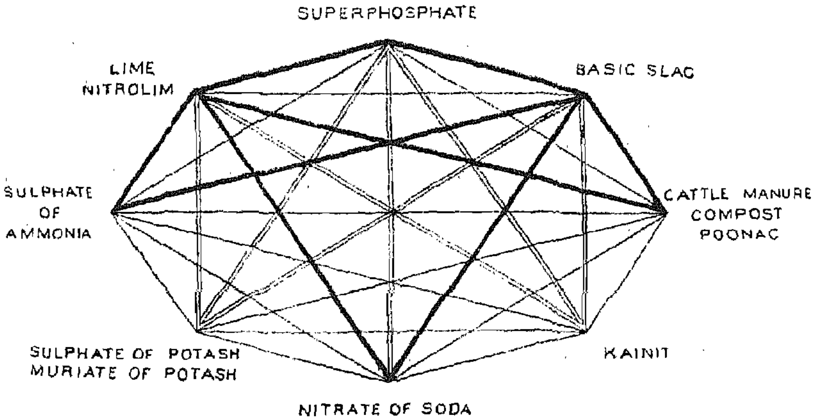


DIAGRAM.

References.—

Should not be mixed.

Can be mixed at any time.

Can be mixed immediately before use.

APPENDIX II.

PREPARATION OF SOME OF THE COMMON FUNGICIDES AND INSECTICIDES.

Bordeaux Mixture.—This is the most important among the fungicides. It is used almost invariably in the form of a liquid and sprayed. Its use in the form of dry powder has been attempted in recent years, but such use is very insignificant, if not almost unknown. The liquid Bordeaux mixture consists of a very fine suspension in water of precipitated Hydroxide of Copper which remains in the liquid in a very finely divided condition and when sprayed covers the parts of the crop on to which it is sprayed as a thin film. This suspension of Copper hydroxide is obtained by the addition of dilute milk of lime to a solution of Sulphate of Copper. In order to make this film spread and adhere firmly a 'spreader' or 'sticker' is added. The mixture is made in different strengths, and the commonest is the one per cent solution also known as 5—5—50 mixture. This is made up of 5 lbs. of copper sulphate, 5 lbs. of lime and 50 gallons (500 lbs.) of water. A two per cent solution is sometimes used, which will be represented by the proportion 5—5—25 and a half per cent solution is also used which will have the proportion 5—5—100. If only small quantities of any strength are required the requisite correct quantities of each can be readily calculated.

The standard or the one per cent solution to give 50 gallons is made as follows :—

(*a*) Copper sulphate solution. Five lbs. of well powdered copper sulphate crystals are dissolved in 25 gallons of water in a wooden tub or a brass, copper or earthenware vessel. For this purpose the copper sulphate may be tied up in a cotton or a gunny bag and suspended in the water from a stick placed across the top of the tub or the vessel. *Iron or zinc vessels should not be used.*

(*b*) Lime. 5 lbs. of quick lime is slaked in a small quantity of water, well stirred up and then more water added to bring up the quantity of the milk of lime to 25 gallons.

(*c*) The mixing of (*a*) and (*b*) takes place in a large barrel or sufficiently large vessel into which (*b*) is first poured and then (*a*) is added slowly with frequent stirring. Other ways of mixing are (1) to pour the two solutions at the same time into the larger vessel, and (2) to pour the copper sulphate (*a*) first and then the milk of lime (*b*).

The mixture will have to be tested to see if it contains any copper sulphate solution (*i.e.*, unprecipitated) by dipping into it the end of a clean iron blade; if the blade becomes coated red, then more milk of lime should be added until no such reddening takes place.

"*Spreader or Sticker*",—There are various materials used for this purpose *viz.*, Resin soda mixture, Casein and lime (Caseinate of lime), Linseed oil, Gingelli' oil, Groundnut oil, or Cocoanut oil.

The Resin soda is made by boiling 2 lbs. of resin and ½ lb. of soda ash in one gallon of water till the mixture is quite clear.

The lime caseinate is made by soaking ½ lb. of casein in half a gallon of water and adding to it half a gallon of milk of lime prepared by slaking ½ lb. of quick lime in half a gallon of water. In the case of the oils, about 1 lb. of the oil is mixed with the copper sulphate solution before the latter is added to the milk of lime.

Spreaders of the above strengths can be added to the Bordeaux mixture 5—5—25, where they will take the place of one gallon of water, the resulting mixture being 5—5—24—1 (Spreader).

(See also pages 464-465 of the text).

Insecticides.

Tobacco Decoction.—Soak 1 lb. of tobacco in two gallons of water, for 24 hours stirring the mass occasionally. Strain or decant and use as a spray. Sometimes soap is added to the tobacco decoction. This tobacco-soap spray is prepared thus;—Boil 1 lb. of tobacco in one gallon of water for half an hour and strain the decoction. Add to it $\frac{1}{4}$ lb. of soap shavings and heat the mixture till the soap dissolves, and cool. The mixture is diluted with six or seven times its own volume of water before being used for spraying.

Kerosene Emulsion.—Dissolve $\frac{1}{2}$ lb. of soap in one gallon of soft water by heating the water to boiling. Remove from the fire, and add 2 gallons of kerosene oil to the hot mixture, and churn it up until it becomes a creamy mass or emulsion, thickens on cooling and adheres to glass without any oil particles separating. Before use the emulsion should be diluted with 20 times its own volume of water.

Lead Arsenate.—The solution is made by dissolving the arsenate in water, in the proportion of 2 lbs. of arsenate for 100 gallons of water.

Fish Oil Soap.—This spray solution is made by dissolving the soap in water in the proportion of 1 lb. of soap to 6 gallons of water.

Honge Oil Soap.—The spray solution with this soap is made by dissolving 1 lb. of the soap in 8 gallons of water.

Calcium Arsenate.—The spray is made by stirring the arsenate in water in the proportion of 1 lb. of the substance to 50 gallons of water. Sometimes the spray is prepared with the addition of lime and jaggery. For this purpose 1 lb. of the arsenate is first made into a paste with water. Two lbs. of lime and 3 lbs. of jaggery are dissolved in sufficient water and strained. The filtrate is then mixed with the arsenate paste and the whole made up to 50 gallons with more water.

Addendum to Chapter I. Rice.

Storage Pests of Rice (to be read with pages 29 and 33 of the Text).—Rice is either stored as paddy (unhusked) or in the husked form, *i.e.*, as rice. If it has to be stored for any thing more than a couple of months or so, then it is kept as paddy and not as rice. In the shape of rice, it undergoes serious deterioration due to both insect pests and to chemical changes. Storage proper (*i.e.*, even then for seldom more than a year, or from one harvest to another) is only in the shape of paddy.

Both paddy and rice are subject to insect pests in storage. Paddy is attacked most frequently by the tiny paddy moth—*Sitatriga Cerealella, O.*—the larvæ of which burrow into and eat the paddy grain reducing the paddy to chaff. The tiny whitish moths are conspicuous in most granaries. The attack is more common when paddy is stored heaped loose upon the floor. If stored in tightly filled bags, metallic or earthenware or wooden bins filled to the brim and covered up preferably by one inch layer of sand or a mixture of sand and lime, the attack can be kept down fairly effectively.

Rice is attacked very badly in storage by the Rice Weevil—*Colandra Oryzoe*, L—of which both the larvæ and the adult feed on the rice and damage it. The pest multiplies rapidly and passes through several generations in a year. Rice is also attacked by another beetle pest, *viz.*, the *Tribolium Castaneum* both the adult and larvæ of which feed on the rice.

A third pest of rice in storage is the flour moth, *Corcyra Cephalnica*, H—the lervæ of which feed on the rice, reducing it to a powder which they web together with the grain into hollow lumps inside of which they hide,

It is very difficult to preserve rice free from these pests. One household remedy consists in keeping it mixed up with turmeric powder. When required for use the rice is screened to remove the turmeric powder, and the washing of the rice previous to cooking it removes some more of the turmeric. The cooked rice is yellow in colour. The preservation of rice under a layer of sand in receptacles provided with a suitable hole at the bottom to tap the rice when wanted, will, as in the case of paddy and many pulses in storage, prove effective.

Both in the case of paddy and rice frequent drying in the sun and cleaning, combined with thorough cleaning of the rooms and receptacles will greatly mitigate the damage.

On a large scale as in the case of godowns, fumigation with Carbon-bi-sulphide will have to be resorted to. About one ounce of Carbon-bi-sulphide for every 15 cubic feet of storage space will be required. The fumigation should be conducted with all precautions against fire, and preferably under expert supervision.

Various dusts are also used for the killing of the weevils in stored produce; these dusts have the property of withdrawing the moisture from the bodies of the weevils and thus causing their death. One such dust recently put out by the Imperial College in London is a chemically prepared fine white powder, which is non-poisonous, free from any risk of causing silicosis and which is claimed to possess extraordinary potency in killing weevils. The addition of this powder at the rate of only 1/10 per cent was found capable of destroying 40 to 50 per cent of the weevils.

Varieties of Rice.—(to be read with page 28 of the text).—In addition to the large number of varieties described there is one variety which may be regarded more or less as a curiosity. In this variety the paddy grain contains two grains of rice and not one as in the case of all the other varieties. This double grained variety can be seen growing in parts of Travancore. As a cultivated rice it is not of much importance; the variety is both delicate and a poor yielder.

ADDENDUM TO SECTION V, CHAPTER III, TAPIOCA.

Varieties.—(to be read with page 259).—Among the varieties under cultivation, is one which unlike those described already, flowers and fruits freely. It is a comparatively low-growing or dwarf variety, branches profusely and has thin stems. The tubers are thin and longish. Indeed the number of types and varieties in Tapioca is very large and quite 25 of such are reported in the crop cultivated in the Travancore State.

APPENDIX III.

List of Books, Journals and other publications consulted.

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2 Handbook of Agriculture by N. G. Mukerji.
3 Text-book of Indian Agriculture by J. Mollison.
4 Dictionary of the Economic Products of India by George Watt.
5 Cyclopaedea of American Agriculture by L. H. Bailey.
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7 Dictionary of Malayan Economic Products, by J. H. Burkill.
8 Tropical Agriculture, by P. L. Simmonds.
9 Tropical Plants by O. W. Barret.
10 Travels in Mysore and Coorg by Buchanan.
11 Handbook of Java, Division of Commerce, Buitenzorg, Java.
12 Field, garden and orchard crops of the Bombay Presidency, by G. A. Gammie.
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14 The Cocoanut Palm, by H. C. Sampson.
15 Food-grains of India by A. H. Church.
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17 The Nutritive Value of Indian Foods by W. R. Aykroyd.
18 Commercial Fertilisers by Gilbert H. Collins.
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21 Organic Chemistry by Paul Karrer.
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39 Spices by Henry N. Ridley.
40 Handbook of Sericulture, I. Rearing of Silkworms by M. Yonemura and N. Rama Rao.
41 Report on the Marketing and Transport of Jute in India.
42 Cultivation and Preparation of Para Rubber by W. H. Johnson.
43 Hevea Brasiliensis or Para Rubber by Herbert Wright.
44 Report on the Rubber Regulation Scheme in India.

45 Indian Tea, its culture and manufacture by Claud Bald.
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47 Report on the Marketing of Wheat in India.
48 Do do Potatoes do
49 Do do Groundnuts in India
50 Do do Linseed do
51 Do do Tobacco do
52 Tobacco Leaf by J. B. Killebrew and Herbert Myrick.
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55 Do do Annual Reports.
56 Journal of the Mysore Agricultural and Experimental Union.
57 Do Madras Agricultural Students' Union.
58 Indian Journal of Agricultural Research.
59 Indian Farming.
60 Mysore Economic Journal.
61 Bulletins of the Tea Research Station, Devashola.
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63 Bulletins of the Sericultural Department in Mysore.
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65 Malayan Agricultural Journal.
66 Tropical Agriculturist.
67 Tropical Agriculture.
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69 Journal of the American Society of Technology.
70 Sea-borne Trade of British India.
71 Crop and Season Reports of the Mysore State.
72 Review of the Rail-borne Trade of Mysore.
73 Imperial Institute Bulletins, London.
74 International Review of Agriculture, Rome.
75 The Philippine Agriculturist.

APPENDIX IV.

Glossary of Vernacular terms used in the text.

Avare ... *Dolichos lab-lab.*
Baragu ... *Panicum miliare.*
Bhatta ... Paddy.
Bili ... White.
Besike ... Hot weather.
Crore ... Ten millions.
Chandrike ... Spinning frame for silk worms.
Dhal ... Split pulse.
Dhaincha ... *Sesbania aculeata.*
Ganja ... *Cannabis sativa* resin.
Ghauts ... Mountain or hill ranges.
Ghosha ... In seclusion, said of women.
Gingelli ... *Sesamum indicum.*
Gunny ... Hessian.
Hain ... The main season, generally from June to December.
Hingar ... The season of the N.E. monsoon.
Honge ... *Pongamia glabra.*
Jola ... *Andropogon sorghum.*
Kar ... The early season, as opposed to *hain*, usually April to July.
Kari ... Black.
Karthik ... The rainy season, from July to December.
Koradu ... Log for levelling and clod crushing.
Kunte ... Harrow.
Lakh ... One hundred thousand.
Maidan ... Open plain country.
Malnad ... Hilly forest country of heavy rainfall.
Maund ... A unit of weight; standard maund—about $82\frac{1}{2}$ lbs.; Mysore maund or local - about 25 lbs. (many local variations).
Mungar ... Season from May to September, of the S. W. monsoon.
Navane ... *Setaria italica.*
Neem ... *Melia azhadirachta.*
Palla ... A unit of volume, equal to 100 Mysore seers.
Pundi ... *Hibiscus cannabinus.*
Poonac ... Oilcake.
Ragi ... *Eleusine coracana.*
Sadde ... One row seed drill.
Sajje ... *Pennisetum typhoideum.*
Save ... *Panicum miliare.*
Seer ... A unit of volume equal to about a quart; also a unit of weight' standard seer is equal to about 2 lbs.; Mysore seer is about 5/8 lb. but has local variations.
Togare ... *Cajanus indicus.*
Vaisak ... The hot weather season; as applied to rice, from January to May.
Tola ... A unit of weight, equal to 180 grains.
Yedekunte ... Interculturing harrow.

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